BOONTON ELECTRONICS CORPORATION

INSTRUCTION MANUAL

FM-AM SIGNAL GENERATOR MODEL 102A

INSTRUCTION MANUAL

FM-AM
SIGNAL GENERATOR
MODEL 102A

BOONTON ELECTRONICS
CORPORATION

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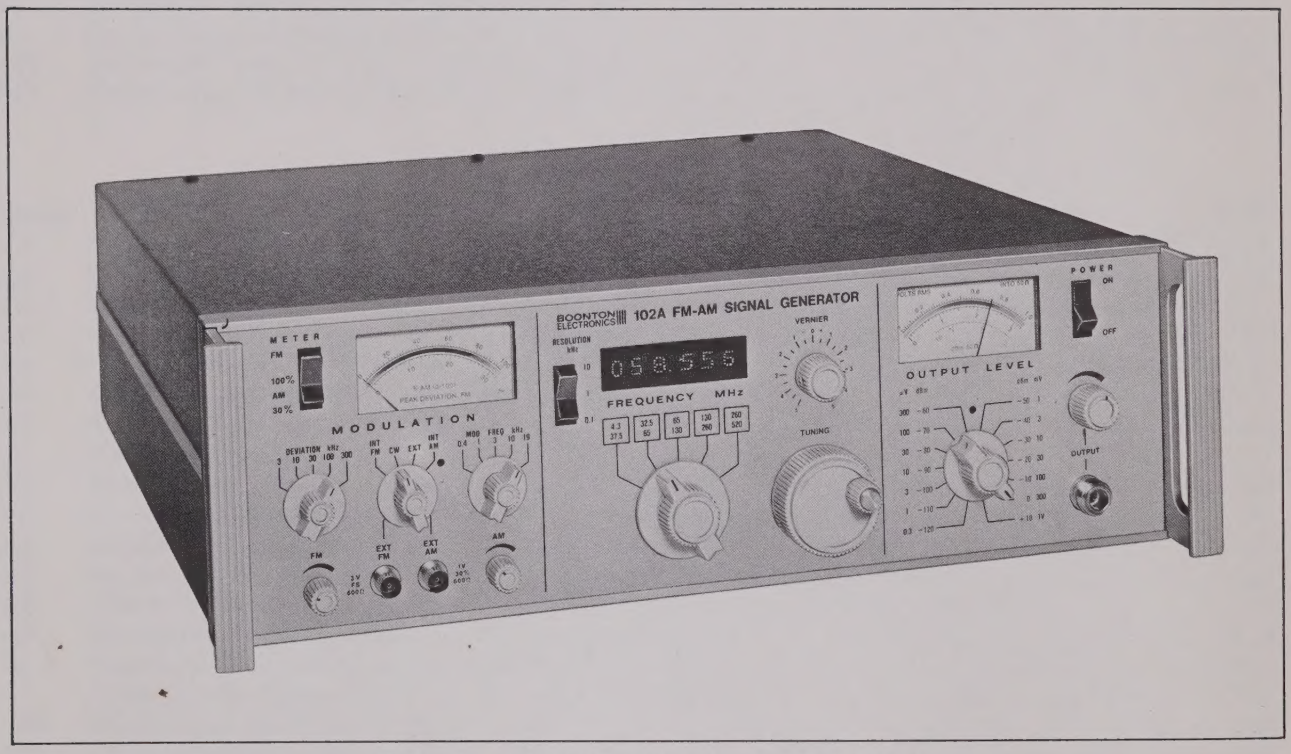


Figure 1-1 FM-AM Signal Generator, Model 102A

SECTION I

INTRODUCTION

1-1. SCOPE OF MANUAL

1-2. This handbook provides descriptive data, operating instructions, theory of operation, maintenance instructions, and a parts list for the Model 102A FM-AM Signal Generator. (See Figure 1-1). The Model 102A is manufactured by Boonton Electronics Corporation, Parsippany, New Jersey.

1-3. PURPOSE AND USE OF EQUIPMENT.

1-4. The Model 102A is a highly versatile, precision, solid-state instrument with features and performance characteristics especially suitable for laboratory and industrial applications. It covers the frequency range of 4.3 to 520 MHz. Human engineering considerations have been emphasized in both the mechanical and electrical design of the Model 102A. The result is an instrument that is easy and convenient to use, despite its flexibility. Among the outstanding design features are:

a. **Spectral Purity.** The spectral purity of the Model 102A is comparable to that of a crystal oscillator. (See Figure 1-2.) The output frequency is derived from an inductively tuned VFO with inherently low microphonism. Appropriate filters are electronically switched into the frequency generating circuits by means of PIN diodes to further suppress spurious frequencies. The suppression of harmonics and other spurious frequencies provides assurance that test results obtained using this instrument will reflect selected test parameters only; erroneous test indications resulting from spurious frequencies are unlikely.

b. **Stability.** The Model 102A exhibits outstanding stability characteristics, both short-term and long-term. Electronic band-switching by means of PIN diodes eliminates a major source of instability and allows immediate use of each band without further stabilization. Design specifications limit drift to a maximum of 20 ppm/10 min after 1 hour warm-up on bands 2 through 5, and 1.5 kHz/10 min after 1 hour warm-up

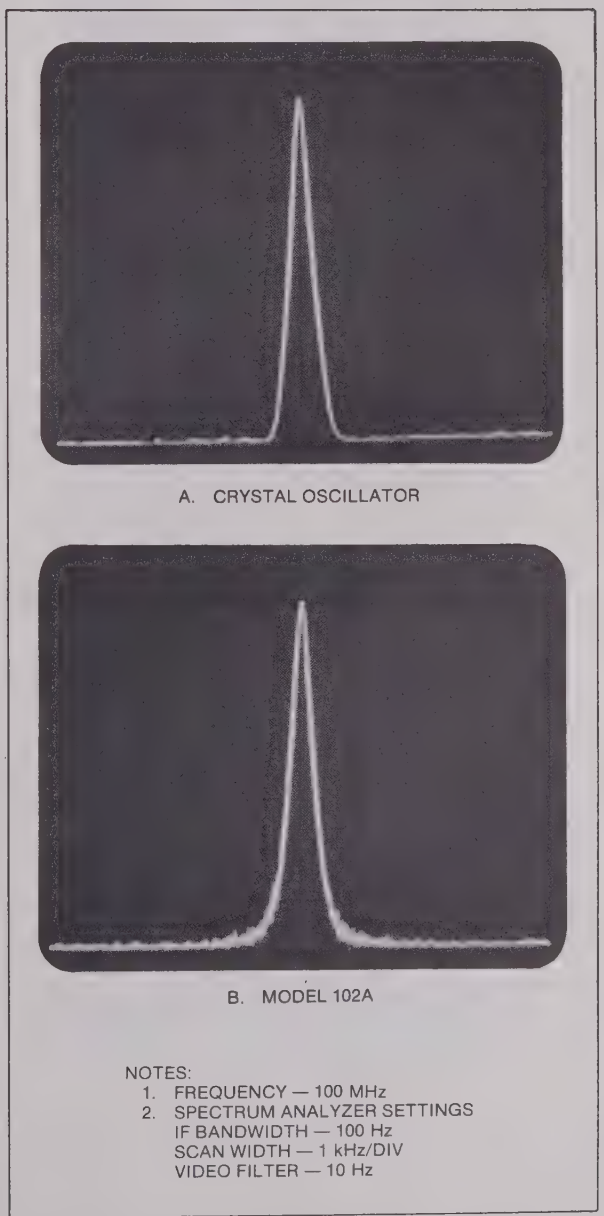


Figure 1-2 Spectrum Comparison, Model 102A and Crystal Oscillator

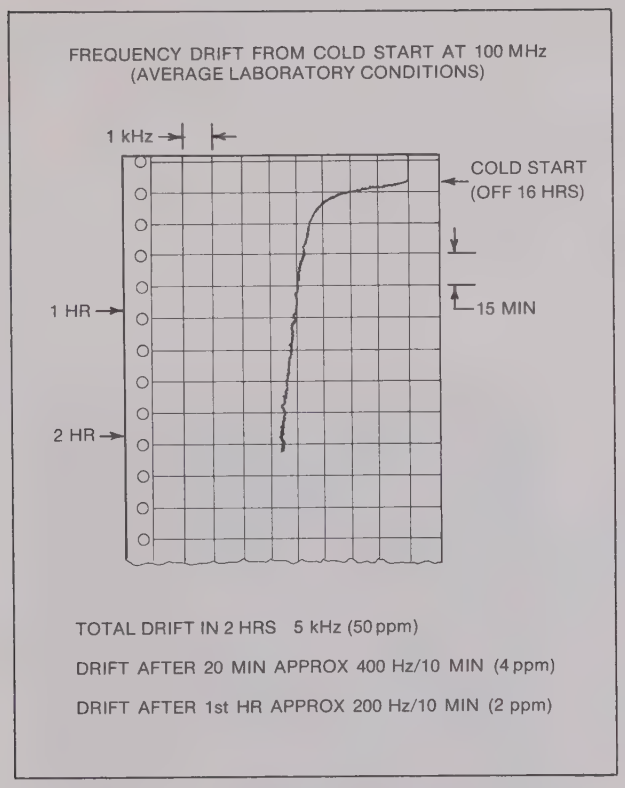

FREQUENCY DRIFT FROM COLD START AT 100 MHz
(AVERAGE LABORATORY CONDITIONS)
1 kHz
COLD START
(OFF 16 HRS)
1 HR
15 MIN
2 HR
TOTAL DRIFT IN 2 HRS 5 kHz (50 ppm)
DRIFT AFTER 20 MIN APPROX 400 Hz/10 MIN (4 ppm)
DRIFT AFTER 1st HR APPROX 200 Hz/10 MIN (2 ppm)

Figure 1-3 Stability Characteristics of Production Model

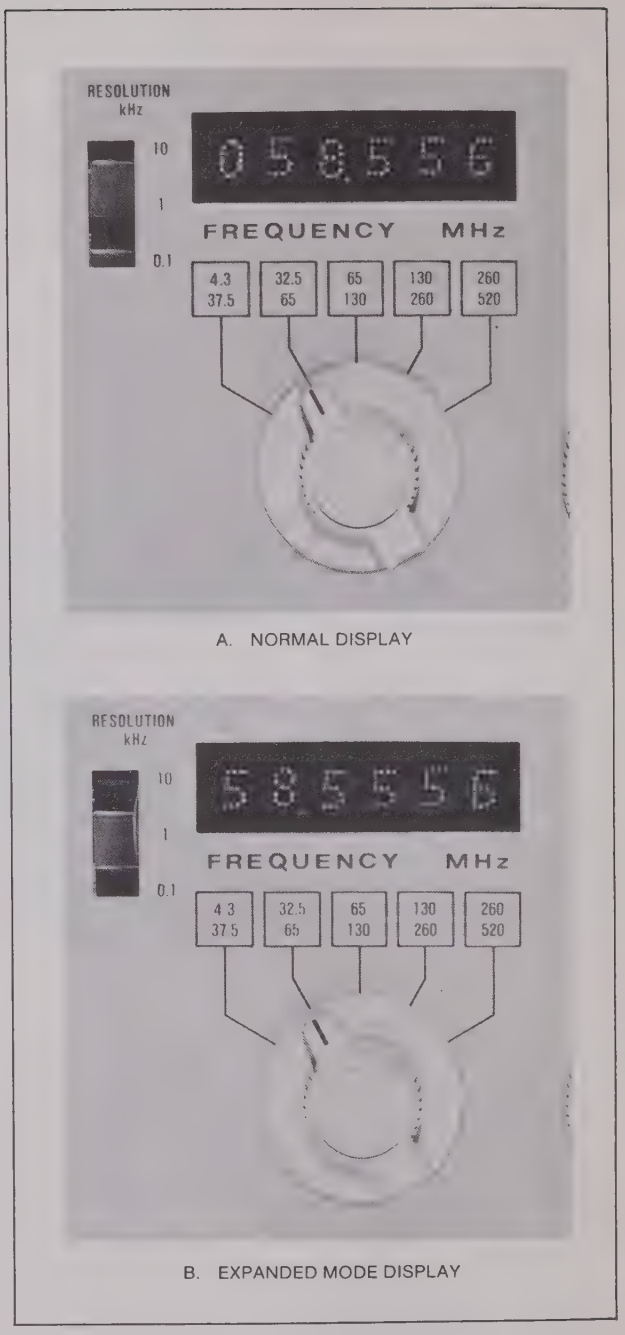


Figure 1-4 LED Frequency Display

on band 1. Actual drift of a production model is shown in Figure 1-3. The stability of the Model 102A minimizes the need for extended, time-consuming warm-up periods and for constant readjustment of the output frequency during use.

c. **LED Frequency Display.** The output frequency of the Model 102A is continually displayed during use by means of a 6-digit LED display. The elimination of a tuning dial, with its recalibration problems and inherent reading uncertainty, removes a major source of operator error. The LED display provides clear, unambiguous readings with selectable resolution, minimizing the possibility of misinterpretation. (See Figure 1-4.) Resolution of 0.1, 1. or 10 kHz can be selected by means of a front-panel switch.

d. **FM/AM Modulation Capabilities.** (See Figure 1-5.) The Model 102A is the ideal instrument for a wide variety of test applications because of its flexible modulation capabilities. FM and AM, using either internal or external modulation signals, can be used either singly or simultaneously. FM deviation is calibrated to an exceptionally wide 300 kHz in five ranges, and can be increased to over 1 MHz uncalibrated. The FM bandwidth extends from dc to 200 kHz. Deviation is adjustable, metered, and constant with band and frequency changes. Distortion and residual and incidental FM are very low, thus the Model 102A is an excellent signal source for both wide-band measurements and narrow-band applications. AM is ad-

justable to 100 percent with low distortion (typically less than 3 percent Total Harmonic Distortion (THD) at 90 percent modulation). The AM bandwidth extends from dc to 20 kHz. Although the Model 102A has not been specifically designed for pulse modulation, good results have been obtained using external low-frequency pulses for modulation.

1-5. The features described in the preceding paragraph, together with those specified in Table 1-1, make the Model 102A particularly useful for design, production line, and field testing in the FM receiver, communications, aerospace, and navaid industries. Because of its flexibility, the Model 102A is also an excellent general-purpose signal generator for laboratory applications.

1-6. OPTIONS.

1-7. Four options are currently available. They are:

Option No.	Description
01	External modulation connectors and RF connector are mounted on the rear panel.
02	Special internal modulation frequencies within the range of 20 Hz to 100 kHz are provided.
03	Detected AM, isolated by a voltage follower, is available at a rear panel BNC connector.
04	RF output is fused to protect the Model 102A from serious damage when external power inadvertently applied to the r-f output connector exceeds 1 watt. Two fuses are supplied; one installed, and one spare.

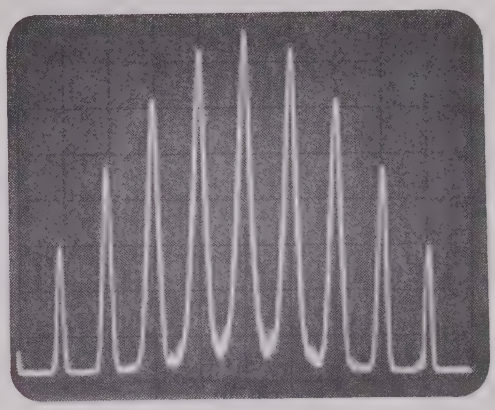
1-8. Inquiries regarding special applications of the Model 102A to specific customer requirements are invited. Direct such inquiries to the Applications Engineering Department of Boonton Electronics Corporation.

1-9. SPECIFICATIONS.

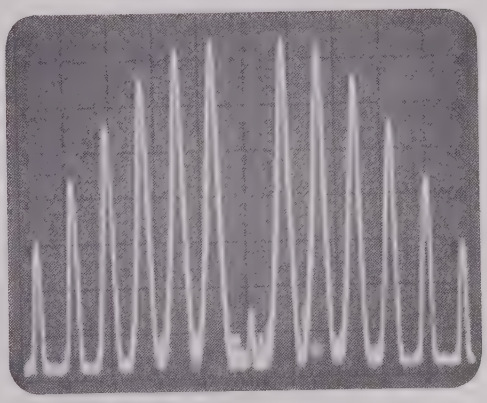
1-10. Pertinent performance specifications of the Model 102A are listed in Table 1-1.

1-11. OUTLINE DIMENSIONS.

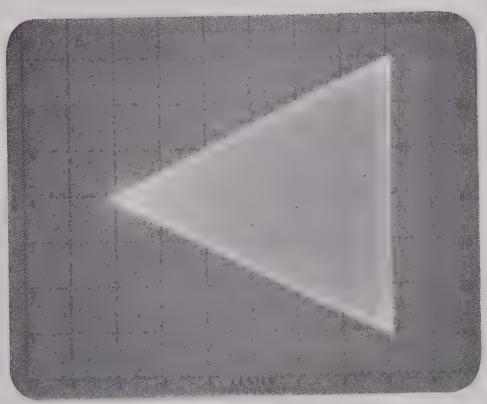
1-12. Outline dimensions of the Model 102A are shown in figure 1-6.



A. FM SIDEBANDS
MODULATION FREQ — 20 kHz
FM DEVIATION — 22.5 kHz PEAK



B. FM WITH CARRIER AT FIRST BESSEL ZERO
MODULATION FREQ — 41.58 kHz
FM DEVIATION — 100 kHz PEAK
MODULATION INDEX — 2.4048



C. 100% AM TRAPEZOID
FREQ — 105 MHz
MODULATION FREQ — 3 kHz
OUTPUT LEVEL — +10 dBm

Figure 1-5 FM/AM Modulation Characteristics

TABLE 1-1. PERFORMANCE SPECIFICATIONS

Parameter	Specifications
OUTPUT FREQUENCY:	
Range	4.3 to 520 MHz in 5 bands: Band 1—4.3 to 37.5 MHz; Band 2—32.5 to 65 MHz; Band 3—65 to 130 MHz; Band 4—130 to 260 MHz; and Band 5—260 to 520 MHz
Accuracy	±(100 Hz + 3 ppm) at 20 to 30°C; can be readjusted to an external frequency standard
Resolution	Selectable, 0.1 kHz, 1 kHz, or 10 kHz
Display	6-digit LED
Stability:	
Bands 2 through 5	Drift less than 20 ppm/10 min after 1 hour warmup (typically, less than 10 ppm/10 min after 2 hour warmup, and less than 2 ppm/10 min after 4 hour warmup)
Band 1	Drift less than 1.5 kHz/10 min after 1 hour warmup
Fine Tuning	Electronic vernier, approximate range of 12.5 kHz on bands 1 and 2, 25 kHz on band 3, 50 kHz on band 4, and 100 kHz on band 5
Residual FM	Less than 20 Hz peak, band 1; less than 0.25 ppm peak, bands 2 through 5 (both in 20 Hz to 15 kHz post-detection bandwidth)
RF OUTPUT:	
Power Level	-130 dBm to +13 dBm (0.07 microvolt to 1 volt into 50 ohms)
Attenuator	13 steps in 10 dB / step plus variable 13 dB calibrated on output meter
Accuracy	+(1.0 dB + attenuator accuracy) (Attenuator accuracy is 0.1 dB / 10 dB step, with maximum cumulative error of ±1.0 dB)
Leveling	±0.5 dB maximum variation across each band
Spurious Outputs	Harmonics, better than -30 dB Sub-harmonically related, better than -40 dB Mixing products (band 1), better than -30 dB (All at settings between 0 and -10 dBm on output vernier range)
Impedance	50 ohms, with VSWR less than 1.5:1 at levels below 0 dBm
Single Sideband Phase Noise	Bands 1 through 3, more than 120 dB/Hz below carrier (typically 125 dB/Hz, 20 kHz off carrier) Bands 4 and 5, more than 105 dB/Hz below carrier (typically 115 dB/Hz, 20 kHz off carrier)
Single Sideband Noise Floor	Typically 130 dB/Hz below carrier

TABLE 1-1. PERFORMANCE SPECIFICATIONS (Cont)

Parameter	Specifications
FREQUENCY MODULATION:	
Deviation	0 to 300 kHz peak, calibrated; more than 1 MHz peak, uncalibrated (all bands)
Ranges	3 kHz, 10 kHz, 30 kHz, 100 kHz, and 300 kHz peak fs, metered by true peak reading meter
Accuracy	±10% fs, 20 Hz to 20 kHz, ±15% fs to 200 kHz
Bandwidth	DC to 200 kHz (3 dB bandwidth, ref. to 10 kHz)
Distortion (at 100 kHz peak deviation)	2.0% maximum THD, bands 1 and 2; 1.0% maximum THD, band 3; 0.7% maximum THD, band 4; 0.5% maximum THD, band 5
External Modulation Input	Nominal 3 volts rms into 600 ohms for fs deviation
Incidental AM with FM	Less than 0.25% AM at 100 kHz deviation
AMPLITUDE MODULATION:	
Percent	0 to 100 for less than +10 dBm at settings between 0 and -10 dBm on output vernier
Calibrated Ranges	30% and 100% fs, true peak reading meter
Accuracy	± 3% AM at 30% and 50% AM (at 400 Hz and 1 kHz rates)
Bandwidth	DC to 20 kHz (+0.5 dB, -2.0 dB, ref. to 1 kHz)
Distortion (at 1 kHz modulation rate)	Less than 1.0% THD at 30% AM Less than 2.0% THD at 70% AM Typically less than 3% at 90% AM
External Modulation Input	Nominal 1 volt rms into 600 ohms for 30% AM
Incidental FM with 30% AM	Less than 50 Hz peak on bands 1 and 2 Less than 1 ppm peak on bands 3 through 5
INTERNAL MODULATION:	
Frequencies	400 Hz, 1 kHz, 3 kHz, 10 kHz, and 19 kHz
Accuracy	± 3%
Distortion	Less than 0.3% THD
Output	Nominal 1.0 volt rms into 600 ohms (rear panel BNC connector)
SIMULTANEOUS MODULATION CAPABILITY	External FM, internal AM External FM, external AM Internal FM, external AM

TABLE 1-1. PERFORMANCE SPECIFICATIONS (Cont)

Parameter	Specifications
GENERAL:	
Power	115/230 volts, 50 to 400 Hz, 30 watts
Dimensions	5-1/4 in. (13.4 cm) high, 17-1/4 in. (43.9 cm) wide, 18-1/8 in. (46.1 cm) deep
Weight	30 pounds (13.6 kg)
Temperature range	0°C to +50°C operating
Available accessories	Rack mounting kit

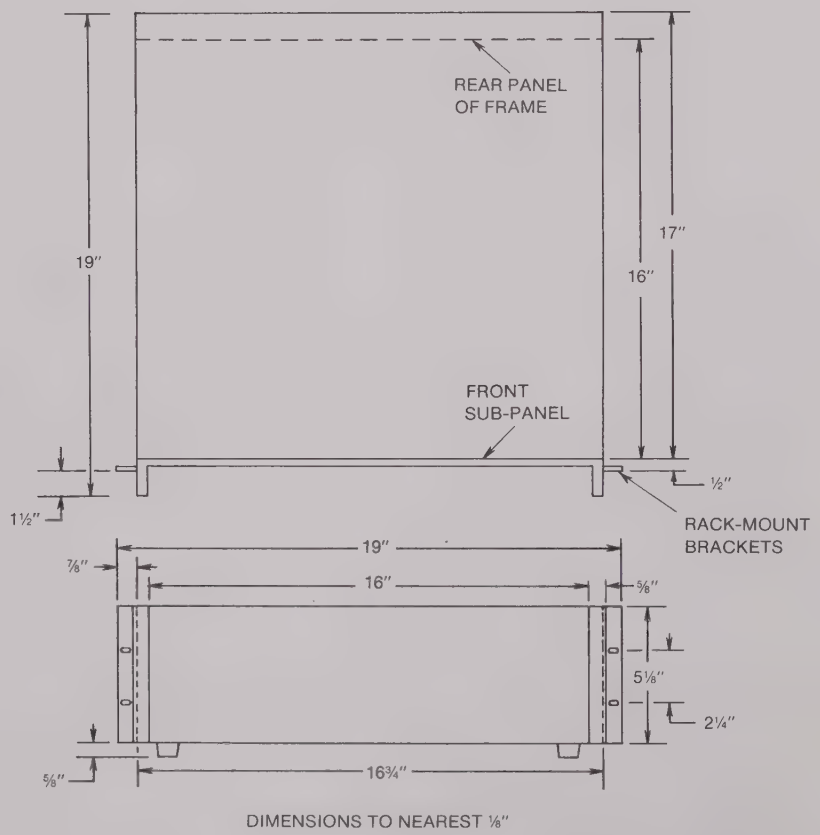


Figure 1-6 Outline Dimensions

SECTION II
OPERATION

2-1. GENERAL

2-2. This section contains instructions for the installation and operation of FM-AM Signal Generator, Model 102A. Although the design of the Model 102A reflects careful attention to human engineering factors regarding ease of use, it is strongly recommended that the operator familiarize himself with the material in this section before attempting to operate the equipment; otherwise, the full capabilities of the equipment may not be realized in use.

2-3. INSTALLATION

2-4. Unpacking. The Model 102A is shipped complete and is ready for use upon receipt. Packaging details are shown in Figure 2-1. Unpack the equipment from the shipping container and inspect it for damage that may have occurred during shipment. Check that all operating controls operate over their full range without binding.

NOTE

Save the packing material and container for possible use in reshipment of the equipment.

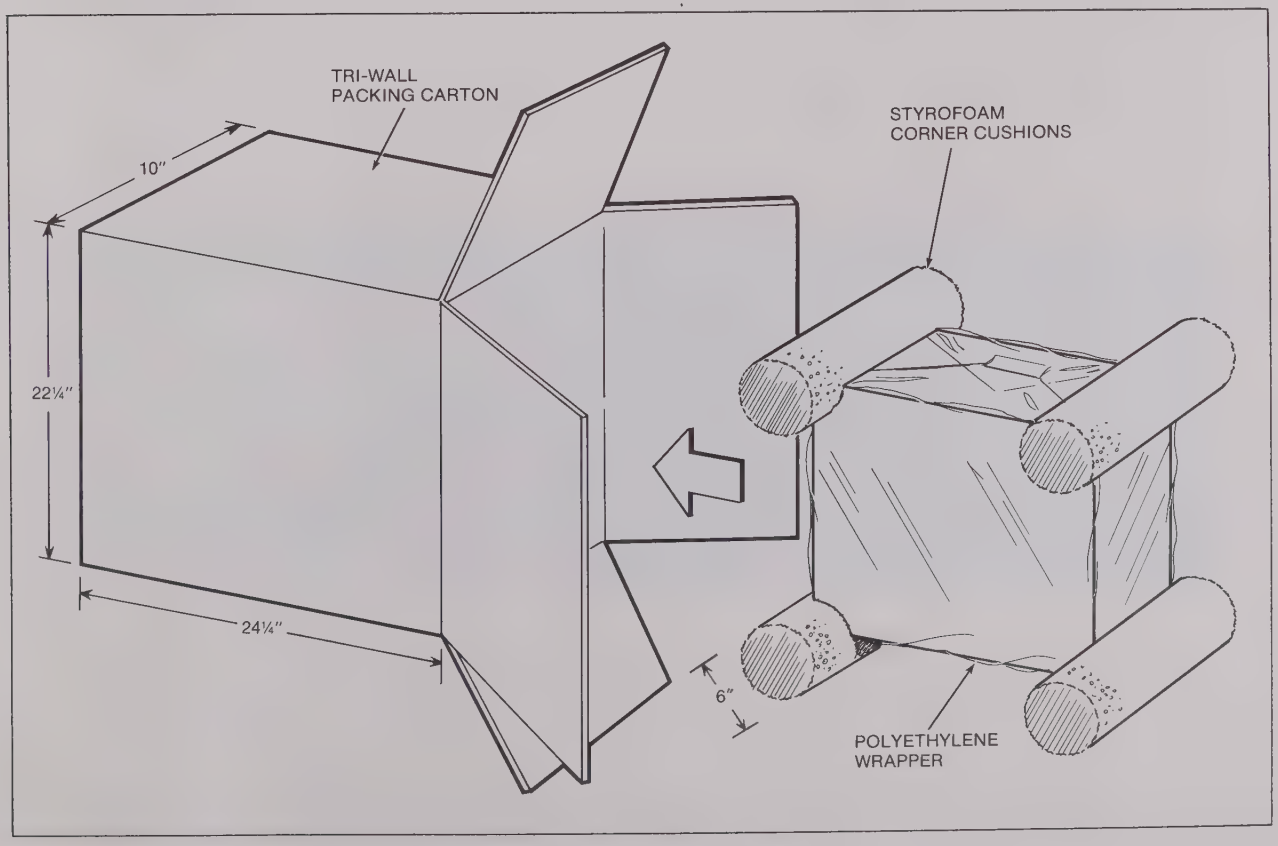


Figure 2-1 Packaging Diagram

2-5. Mounting. For bench mounting, choose a clean, sturdy, uncluttered mounting surface. See Figure 1-6 for space requirements. For rack mounting, install the accessory rack mounting brackets on the Model 102A, install the equipment in the rack, and secure the mounting brackets to the rack frame. Allow adequate space at the rear for making cable connections.

2-6. Power Requirements. A 115 or 230 volt, 50 to 400 Hz, single phase, ac power source is required for operation of the Model 102A. Power required is 30 watts.

CAUTION

Always make certain that the line voltage switch on the rear panel of the Model 102A is set to the appropriate position (0.50 A for 115 volts; 0.25 A for 230 volts) and that a fuse of the corresponding rating is installed in the fuse holder on the rear panel before connecting the Model 102A to any ac power source.

2-7. Cable Connections. Various cable connections, depending upon the operating mode of the Model 102A, are required. Connecting cables are not supplied with the equipment. Cable connections that may be required are as follows:

a. **Output.** The r-f output of the Model 102A is available at the front panel OUTPUT connector (type N). Output impedance is 50 ohms. For operation with load impedances other than 50 ohms, refer to paragraph 2-22.

b. **FM Input.** If the Model 102A is to be frequency modulated by an external signal, connect the external signal source to the front panel EXT FM connector (type BNC). Input impedance is 600 ohms, and a nominal 3-volt rms signal is required for fs deviation.

c. **AM Input.** If the Model 102A is to be amplitude modulated by an external signal, connect the external signal source to the front panel EXT AM connector (type BNC). Input impedance is 600 ohms, and a nominal 1-volt rms signal is required for 30 percent AM.

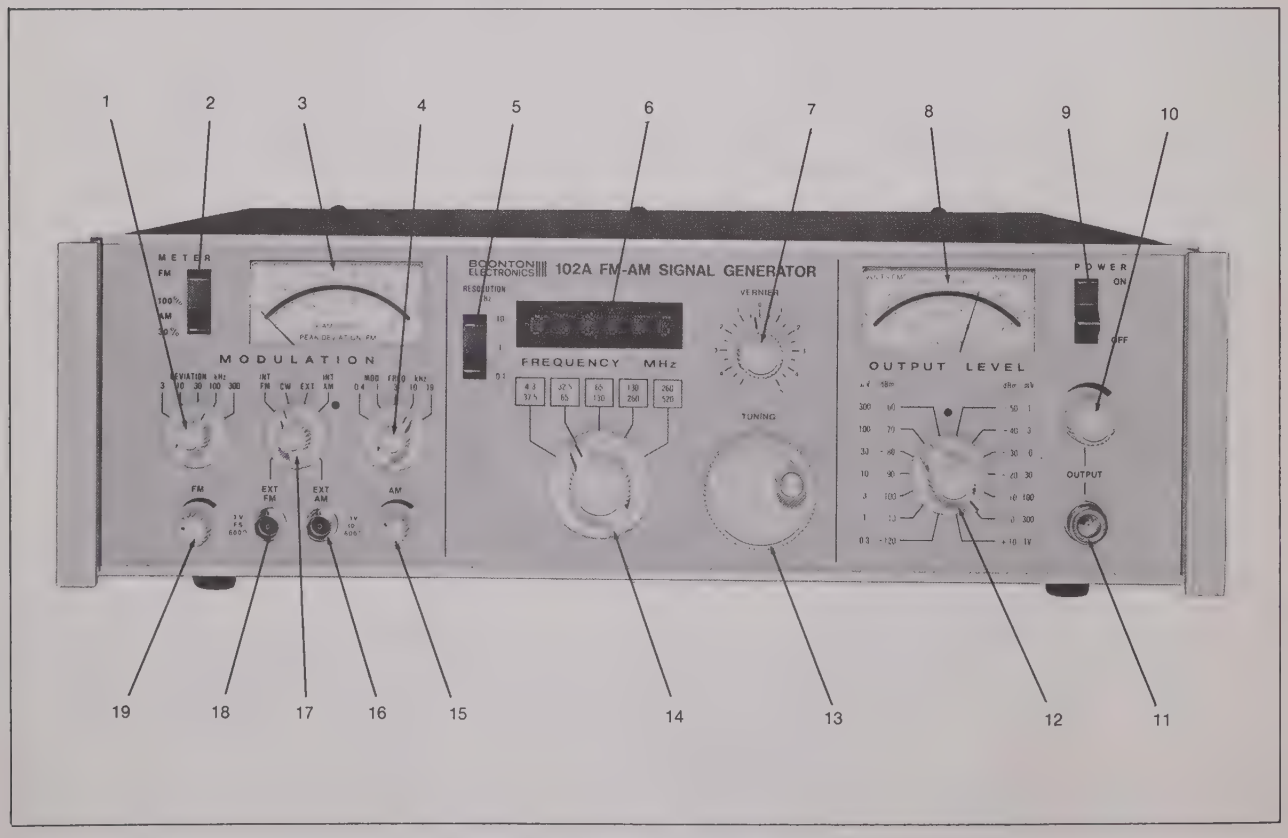


Figure 2-2 Model 102A, Front View

d. **Modulating Signal Output.** An isolated output signal from the internal modulation oscillator is available at the rear-panel MOD FREQ OUT connector (type BNC). Output impedance is 600 ohms, and the nominal amplitude of the signal is 1 volt rms.

2-8. OPERATING CONTROLS, INDICATORS, AND CONNECTORS.

2-9. All controls, indicators, and connectors used during operation of the Model 102A are shown in Figures 2-2 and 2-3. Table 2-1 lists their functions.

TABLE 2-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS

Control, Indicator or Connector	Figure and Index No.	Function
DEVIATION kHz switch	2-2, 1	Permits operator to select peak deviation limit for either external or internal FM. Actual FM deviation is adjustable from zero to selected limit by means of FM control.
METER switch	2-2, 2	Permits operator to select MODULATION meter function. When switch is set to either AM position, MODULATION meter indicates percentage of AM; when switch is set to FM, meter indicates frequency deviation.

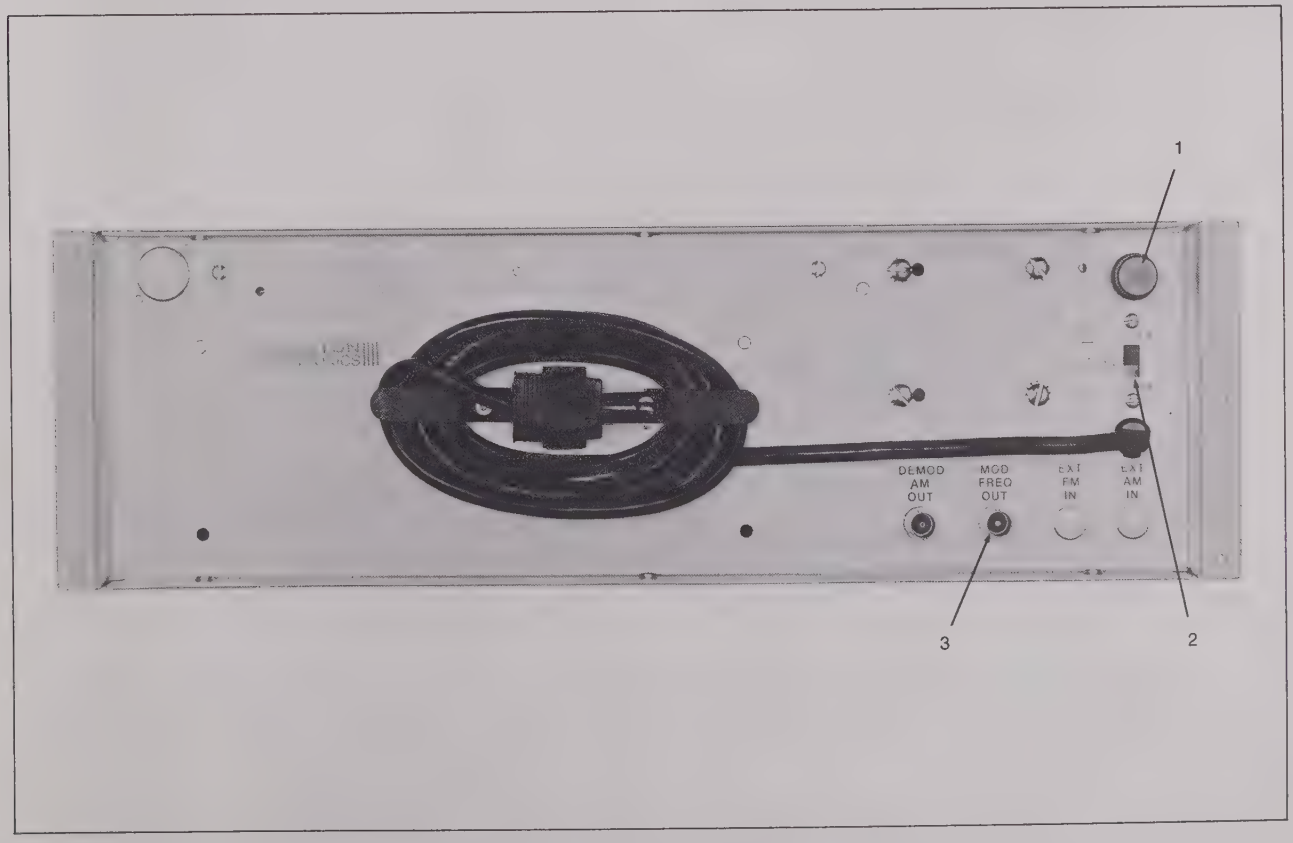


Figure 2-3 Model 102A, Rear View

TABLE 2-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS (Cont)

Control, Indicator, or Connector	Figure and Index No.	Function
MODULATION meter	2-2, 3	Measures either percentage of AM, or frequency deviation, as determined by setting of METER switch. Percentage of AM is indicated on lower scale for 30% AM switch position, and on upper scale for 100% switch position. Frequency deviation is indicated on lower scale for DEVIATION kHz switch settings of 3, 30, and 300 kHz, and on upper scale for switch settings of 10 and 100 kHz.
MOD FREQ kHz switch	2-2, 4	Permits operator to select any one of five internal modulating frequencies (0.4 kHz, 1 kHz, 3 kHz, 10 kHz, or 19 kHz) for either AM or FM.
RESOLUTION kHz switch	2-2, 5	Permits operator to select resolution of output frequency indicator display for precise measurement of output frequency. In 10 position, output frequency indicator display includes 2 decimal places; in 1 position, 3 decimal places; and in 0.1 position, 4 decimal places.
Output frequency indicator	2-2, 6	Indicates output frequency of Model 102A by means of 6 digit LED display. Resolution is determined by setting of RESOLUTION kHz switch.
VERNIER control	2-2, 7	Permits operator to fine-tune output frequency over a range approximately ±0.01 percent of output frequency. On bands 2 through 5, clockwise rotation increases output frequency; on band 1, clockwise rotation decreases output frequency.
OUTPUT LEVEL meter	2-2, 8	Indicates output level of Model 102A in either volts or dBm into 50 ohms. Top scale is used for 10-series settings of OUTPUT LEVEL attenuator, middle scale is used for 3-series settings, and bottom scale for dBm indications. dBm output level is sum of meter reading and dBm setting of OUTPUT LEVEL attenuator.
POWER switch	2-2, 9	RED AREA ON OUT PUT METER INDICATES LIMITS FOR AM Permits operator to control application of input ac power.
OUTPUT control	2-2, 10	Permits operator to adjust output level to values between those obtainable using OUTPUT LEVEL attenuator, or to calibrate output level to values corresponding to OUTPUT LEVEL attenuator setting.
OUTPUT connector	2-2, 11	Provides means for connecting output signal of Model 102A to load. Output impedance is 50 ohms.
OUTPUT LEVEL attenuator	2-2, 12	Permits operator to adjust output level in 10 dB steps.
TUNING control	2-2, 13	Permits operator to select output frequency within band selected by means of FREQUENCY MHz switch. On bands 2 through 5, output frequency increases with clockwise rotation of TUNING control; on band 1, frequency decreases with clockwise rotation.

TABLE 2-1. OPERATING CONTROLS, INDICATORS, AND CONNECTORS (Cont)

Control, Indicator, or Connector	Figure and Index. No.	Function
FREQUENCY MHz switch	2-2, 14	Permits operator to select desired output frequency band.
AM control	2-2, 15	Permits operator to adjust percentage of AM.
EXT AM connector	2-2, 16	Provides means for connecting external modulating signal source for external AM functions of Model 102A.
MODULATION function switch	2-2, 17	Permits operator to select modulation mode as detailed below: INT FM - FM, using internal modulation oscillator, is selected. External AM can be used simultaneously. CW - Unmodulated output signal is selected. EXT - AM and FM, using external modulation signals, can be used, either singly or simultaneously. INT AM - AM, using internal modulation oscillator, is selected. External FM can be used simultaneously.
EXT FM connector	2-2, 18	Provides means for connecting external modulation signal source for external FM functions of Model 102A.
FM control	2-2, 19	Permits operator to adjust deviation to peak deviation level determined by setting of DEVIATION kHz switch when FM mode is selected.
Power fuse	2-3, 1	Protects Model 102A against overloads.
Line voltage switch	2-3, 2	Connects power input circuits of Model 102A for operation from either 115-volt (0.50A position) or 230-volt (0.25A position) ac power source.
MOD FREQ OUT connector	2-3, 3	Provides isolated output signal from internal modulation oscillator at output impedance of 600 ohms and nominal signal level of 1 volt rms.

2-10. POWER APPLICATION.

2-11. The Model 102A is designed for operation from either a 115-volt or a 230-volt, 50 to 400 Hz, ac power source. To apply power, proceed as follows:

a. Determine the line voltage at the ac power output receptacle and set the rear panel line voltage switch to the corresponding position.

b. Check the value of the fuse in the rear panel fuseholder. For 115-volt operation, the fuse should be a 0.5-ampere, MDL Slo-Blo type; for 230-volt operation, a 0.25-ampere, MDL Slo-Blo type. If the rating of the fuse is incorrect for the available line voltage, install a fuse of the proper rating in the fuseholder.

WARNING

The Model 102A is designed to operate from a 3-terminal (one ground) ac power receptacle. To eliminate a potential shock hazard to operating personnel, use a 3-prong to 2-prong adapter if only a 2-terminal ac power receptacle is available. Connect the ground wire of the adapter to the power receptacle ground.

c. Connect the power cord of the Model 102A (with adapter, if required) to the ac power receptacle.

2-12. PRELIMINARY CHECK.

2-13. Before using the Model 102A, perform a preliminary check as follows:

NOTE

The following checkout procedure is intended merely to ensure that all circuits are operating. If a detailed performance check against major performance specifications is desired, refer to paragraph 2-35.

a. Set the POWER switch to ON.

b. Rotate the OUTPUT control while observing the OUTPUT LEVEL meter. The OUTPUT LEVEL meter indication should be adjustable from full scale down to near zero by means of the OUTPUT control.

c. Set the FREQUENCY MHz switch to 32.5—65, and the TUNING control to any arbitrary setting. Ascertain that the output frequency indicator provides a readout that falls within the selected frequency band. Rotate the VERNIER control and ascertain that the last digit of the output frequency indicator display changes.

d. Set the RESOLUTION kHz switch successively to each of its three positions. With the switch set to 10, the output frequency indicator display should include two digits to the right of the decimal point; with the switch set to 1, three digits; and with the switch set to 0.1, four digits.

e. Set the MODULATION function switch to INT FM, the MOD FREQ kHz switch to 1, and the METER switch to FM. Rotate the FM control and ascertain that peak deviation, as indicated on the MODULATION meter, is adjustable to the peak value indicated by the DEVIATION kHz switch.

f. Set the MODULATION function switch to INT AM and the METER switch to 100% AM. Rotate the AM control and ascertain that the modulation level, as indicated on the MODULATION meter, is adjustable to at least 100 percent.

g. Adjust the OUTPUT control to obtain a 0 dBm indication on the OUTPUT LEVEL meter. Using the TUNING control, tune the Model 102A over one entire band, and ascertain that the indication of the OUTPUT LEVEL meter remains essentially constant over the entire band.

h. Set the FREQUENCY MHz switch successively to each of the four remaining positions and ascertain that, at each switch position, the readout of the output frequency indicator falls within the selected band.

2-14. OPERATING PROCEDURE.

2-15. General. Because of the flexibility of the Model 102A, a number of different operating modes is possible. Regardless of the operating mode selected, however, operation can be divided into four distinct steps: output frequency selection, modulation mode selection, adjustment of modulation levels, and adjustment of output level. Procedures for these steps are given in paragraphs 2-16 through 2-19.

2-16. Output Frequency Selection. To energize the Model 102A and select a particular output frequency, proceed as follows:

a. Set the POWER switch to ON.

b. Set the RESOLUTION kHz switch to 10, and the VERNIER control to 0.

c. Set the FREQUENCY MHz switch to the position that covers the desired output frequency, and adjust the TUNING control until the output frequency indicator displays the desired output frequency. Use the VERNIER control for fine adjustments of the output frequency.

NOTE

On the four uppermost frequency bands, clockwise rotation of the TUNING and VERNIER controls results in an increase in output frequency; on band 1, clockwise rotation of the two controls results in a decrease in the output frequency.

d. If greater resolution of the output frequency indicator display is required, set the RESOLUTION kHz switch to 1 or 0.1, as applicable, and adjust the output frequency precisely to the desired value using the VERNIER control.

NOTE

Operation of the RESOLUTION kHz switch from 1 to 0.1 effectively shifts the display on the output frequency indicator one digit to the left, adding one additional decimal digit. If the selected output frequency is 100 MHz or higher, the most significant digit will be shifted out of the display when the resolution is increased from 1 to 0.1 kHz.

2-17. Modulation Mode Selection. After adjusting the output frequency, select the modulation mode, using the MODULATION function switch. The various possible modulation modes, together with the appropriate switch positions, are as follows:

Modulation Mode	MODULATION Function Switch Position
CW	CW
External AM	EXT
External FM	EXT
External AM, external FM	EXT
Internal AM	INT AM
Internal AM, external FM	INT AM
Internal FM	INT FM
Internal FM, external AM	INT FM

2-18. Adjustment of Modulation Levels. After selecting the modulation mode, adjust the modulation levels in accordance with the following procedures, as applicable:

a. **AM.** Adjust the percentage of AM as follows:

1. If the internal AM mode has been selected, select the desired modulation frequency using the MOD FREQ kHz switch.

2. If the external AM mode has been selected, ascertain that the external signal source is connected to the EXT AM connector, that the frequency (20 kHz maximum) of the external signal source has been adjusted to the desired value, and that the external AM signal level has been adjusted to a value adequate for the desired modulation level (1 volt rms for 30% AM).

3. Set the METER switch to 100% AM.

4. Using the AM control, adjust the percentage of modulation, as indicated on the MODULATION meter, to the desired level. For low modulation levels, set the METER switch to 30% when the indication on the upper scale of the meter drops below 30%.

NOTE

When the METER switch is set to 100% AM, read the upper scale of the MODULATION meter; when the switch is set to 30% AM, read the lower scale.

b. **FM.** Adjust FM deviation as follows:

1. If the internal FM mode has been selected, select the desired modulation frequency using the MOD FREQ kHz switch.

2. If the external FM mode has been selected, ascertain that the external signal source is connected to the EXT FM connector, that the frequency (200 kHz maximum) of the external signal source has been adjusted to the desired value, and that the external FM signal level has been adjusted to a value adequate for the desired deviation (3 volts rms for fs).

3. Select the peak deviation limit, using the DEVIATION kHz switch.

4. Set the METER switch to FM.

5. Using the FM control, adjust the deviation, as indicated on the MODULATION meter, to the desired level.

NOTE

Read the upper scale of the MODULATION meter when the DEVIATION kHz switch is set to 10 or 100; read the lower scale for DEVIATION kHz switch settings of 3, 30, and 300.

2-19. Adjustment of Output Level. Adjust the output level of the Model 102A as follows:

a. The output level, in dBm, is the algebraic sum of the dBm value selected by means of the OUTPUT LEVEL attenuator and the dBm indication on the lowest scale of the OUTPUT LEVEL meter. To obtain a calibrated dBm level corresponding exactly to one of the OUTPUT LEVEL attenuator step values, set the OUTPUT LEVEL attenuator to the desired position, and set the pointer of the OUTPUT LEVEL meter to 0 dBm, using the OUTPUT control. To obtain a dBm output level between the step values of the OUTPUT LEVEL attenuator, set the OUTPUT LEVEL attenuator to the dBm setting nearest the desired output level, and adjust the OUTPUT control, as required, until the difference between the desired dBm value and the OUTPUT LEVEL attenuator setting is indicated on the lowest scale of the OUTPUT meter. For example: to obtain an output level of -32 dBm, set the OUTPUT LEVEL attenuator to -30 dBm, and adjust the OUTPUT control to obtain a -2 dB indication on the OUTPUT LEVEL meter.

NOTE

All output dBm levels are calibrated for a 50-ohm load impedance.The dBm indications are invalid for other load impedances. Refer to paragraph 2-22 if the Model 102A is to be used with load impedances other than 50 ohms.

b. Output voltage levels are indicated directly on the upper scale (for 10-series OUTPUT LEVEL attenuator settings) or the middle scale (for 3-series settings) of the OUTPUT LEVEL meter, using multipliers appropriate for the selected OUTPUT LEVEL attenuator setting. For calibrated output voltage levels corresponding to the OUTPUT LEVEL attenuator step values, set the OUTPUT LEVEL attenuator to the desired position, and adjust the OUTPUT LEVEL meter pointer to 1.0 on the upper scale (10-series attenuator settings) or to 3.0 on the middle scale (3-series attenuator settings), using the OUTPUT control. For output voltage levels between the step values of the OUTPUT LEVEL attenuator, set the attenuator to the output voltage position immediately above the desired output voltage level, and adjust the OUTPUT control as required to obtain the desired output voltage level indication on the appropriate scale of the OUTPUT LEVEL meter. For example: to obtain an output level of 5 mV, set the OUTPUT LEVEL attenuator to 10 mV, and adjust the OUTPUT control to obtain an indication of 0.5 on the top scale of the OUTPUT LEVEL meter.

NOTE

Output voltage indications are not affected by load impedances, but are only correct for 50 ohm loading.

2-20. APPLICATION NOTES.

2-21. General. Paragraphs 2-22 through 2-34 present typical application data for the Model 102A. The Model 102A is an extremely versatile instrument with many possible test applications, including circuit characterization, transmitter simulation, local oscillator substitution, and receiver measurements. Use of the Model 102A is, therefore, in no way restricted to the applications covered in the following paragraphs: the data is included merely to cover a few typical or specialized applications.

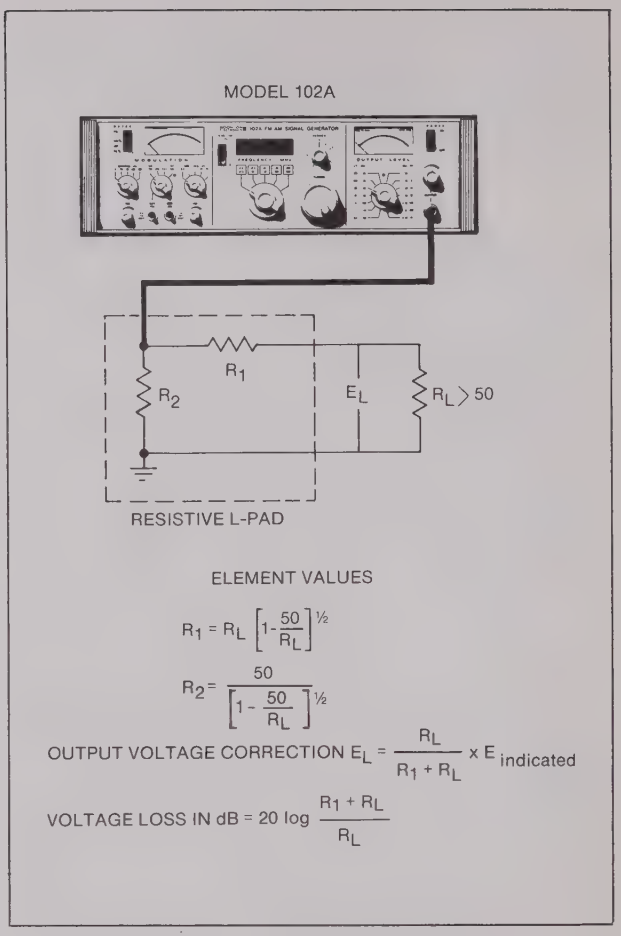


Figure 2-4 Impedance Matching Network for Output Load Impedance Higher Than 50 Ohms

2-22. Impedance Matching. The output circuits of the Model 102A are designed for operation into unbalanced, 50 ohm loads; therefore, the Model 102A can be used to drive most loads directly. The output circuit design, however, does not preclude use with balanced loads, or with loads having impedances other than 50 ohms. When a matching network is employed, an appropriate correction factor must be applied to the readings of the output voltage monitor.

NOTE

The output monitor of the Model 102A will correctly indicate the level at the output terminals of the generator when an impedance matching network is used. The actual signal level at the load, however, may be greater or smaller, according to the na-

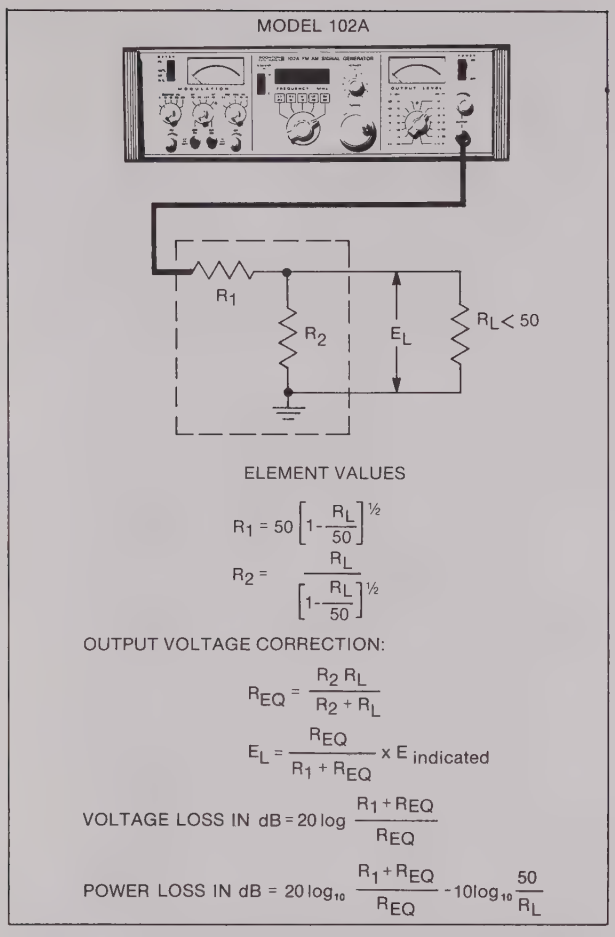

MODEL 102A
R1
R2
EL
RL< 50
ELEMENT VALUES
$R_1 = 50\left[1-\frac{R_L}{50}\right]^{1/2}$
$R_2 = \frac{R_L}{\left[1-\frac{R_L}{50}\right]^{1/2}}$
OUTPUT VOLTAGE CORRECTION:
$R_{EQ} = \frac{R_2 R_L}{R_2 + R_L}$
$E_L = \frac{R_{EQ}}{R_1 + R_{EQ}} \times E_{indicated}$
VOLTAGE LOSS IN dB = $20 \log \frac{R_1 + R_{EQ}}{R_{EQ}}$
POWER LOSS IN dB = $20 \log_{10} \frac{R_1 + R_{EQ}}{R_{EQ}} - 10 \log_{10} \frac{50}{R_L}$

Figure 2-5 Impedance Matching Network for Output Load Impedance Lower Than 50 Ohms

ture of the network. Proper correction factors can be calculated provided the circuit parameters are accurately known. In the event the characteristics of the network are unknown, measurements should be made with a sensitive r-f millivoltmeter, such as the Boonton Electronics Model 92A, between input and output under loaded conditions.

2-23. Consider the case where an output load impedance higher than 50 ohms is required. A network similiar to that shown in Figure 2-4 can be employed.

2.24. For example, if the output load (and source impedance) desired is 75 ohms; R_1 = 43.3 ohms, R_2 = 86.6 ohms and a correction factor of 0.634 or 3.96 dB must be applied to the reading indicated on the Model 102A output voltage indicator. A different correction factor must be applied to determine power delivered to the load because the impedance has been changed.

Power loss (in dB) = $20 \log_{10}(R_1 + R_L)/R_L + 10 \log_{10} R_L/50$

or the delivered power can simply be calculated from: $P = E_L^2/R_L$

In this example, power loss in dB = 3.96 dB + 1.76 dB = 5.72 dB. If the Model 102A output monitor indicates the output level is -10 dBm, the power in the load is -10 dBm -5.72 dBm = -15.72 dBm.

2-25. In cases where a source impedance of less than 50 ohms is required to drive a low impedance load, a minimum loss matching pad of the configuration shown in Figure 2-5 is recommended. The formulas for calculating the values of the matching pad are included as part of Figure 2-5.

2-26. Several standard tests for measuring receiver sensitivity (as defined by EIA Std RS-204-Minimum Standards for Land-Mobile Communication FM or PM Receivers) define the source voltage as that developed at the generator output under open circuit conditions where the generators source impedance is 50 ohms. In Figure 2-6, this will be the voltage measured across terminals A and B when the load is disconnected.

2-27. The Model 102A, however, is calibrated to read the voltage appearing at terminals A and B with a matched 50 ohm load connected. To facilitate this measurement, a matched 6 dB pad of the form shown in Figure 2-7 should be used. With this network connected between the Model 102A and the receiver, the

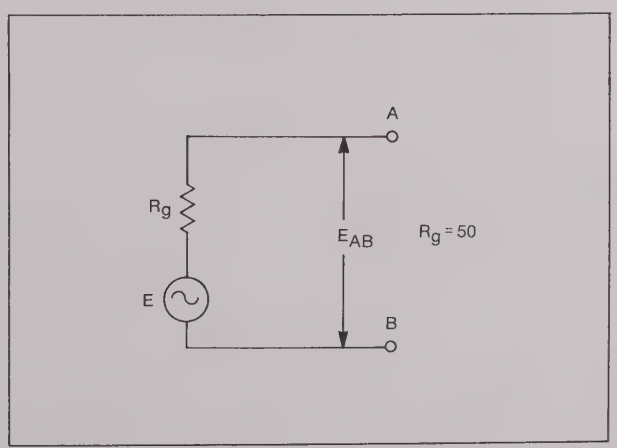


Figure 2-6 Generator Open Circuit Source Voltage

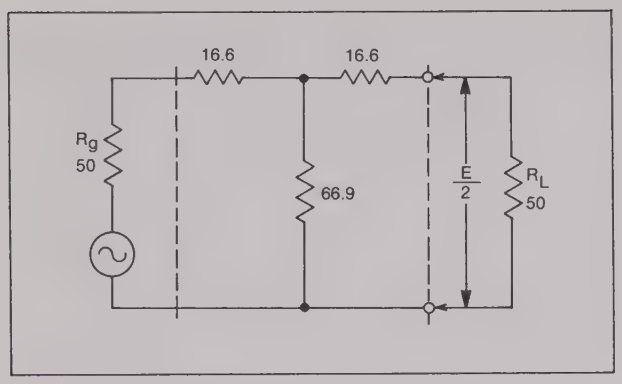


Figure 2-7 Matched 6 dB Pad

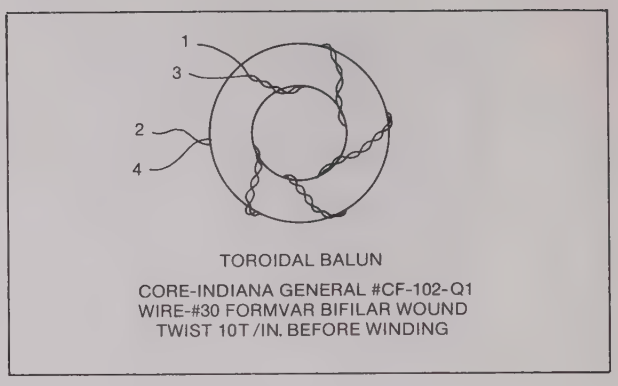


Figure 2-8 Toroidal Balun Construction Details

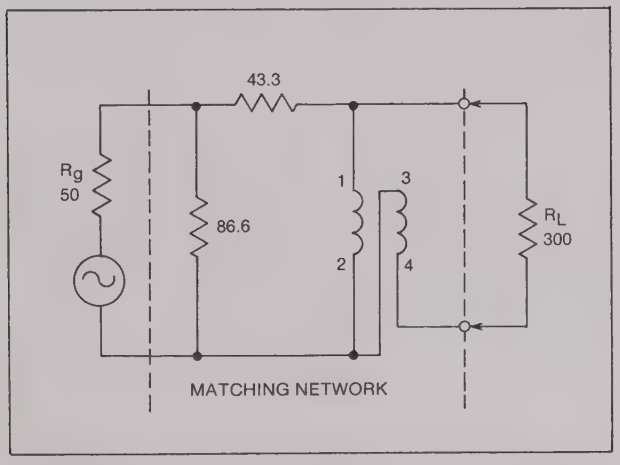


Figure 2-9 300 Ohm Balanced Matching Network

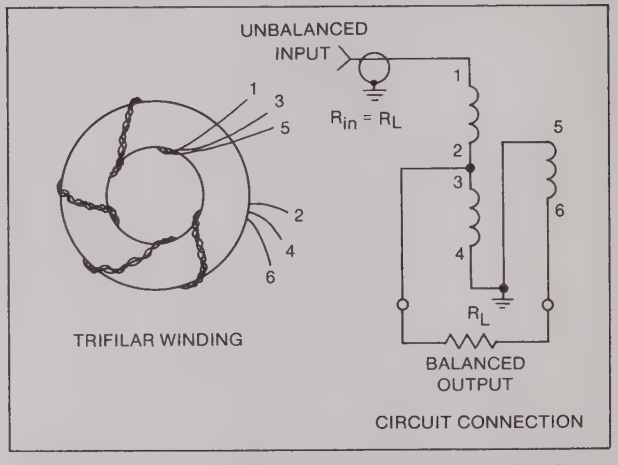


Figure 2-10 Wideband Response 1:1 Toroidal Balun

Model 102A output monitor correctly indicates the open circuit voltage supplied to a 50 ohm *unbalanced* receiver input.

2-28. For connection to receivers with *balanced* input terminals, a balun should be used to provide a balanced output voltage from the Model 102A. For example, assume it is desired to match the Model 102A to a 300 ohm balanced receiver input. First the 50 ohm source impedance of the generator can be converted to a 75 ohm source in a manner described in paragraph 2-24. Next, the 75 ohm unbalanced load output can be connected to a 300 ohm balanced output by use of a 4:1 balun transformer as shown in Figure 2-8. The entire network can then be represented by Figure 2-9. A correction factor for the output voltage must be applied. The 75 ohm section drops the output voltage approximately 4 dB below that indicated by the Model 102A output monitor. The balun, conversely, increases the voltage by 6 dB, assuming it to be lossless. The overall result is a load voltage 2 dB higher than that indicated on the output meter.

2-29. Alternate configurations for balun construction are shown by Figures 2-10 and 2-11. The configuration shown by Figure 2-10 will exhibit a relatively wideband response, while the one shown in Figure 2-11 will have a fairly narrowband range due to the use of a resonant line section.

2-30. IF Response. The wide bandwidth required of many i-f amplifiers is often attained through use of stagger-tuned, or overcoupled, double-tuned circuits. Alignment of such circuits, or checking of their response characteristics is facilitated through use of the Model 102A as a sweep generator. A typical test arrangement is shown in Figure 2-12. For such applications, the external FM mode is generally used. Modulation frequencies from 20 Hz to 100 Hz are recommended. The Model 102A output frequency is adjusted to the center of the i-f pass band, and the deviation is adjusted to the point where the entire response curve of the i-f amplifier is displayed on the oscilloscope. The DEVIATION kHz switch is set at 300 and the METER switch to AM to prevent off-scale reading. Since the horizontal

deflection circuits of the oscilloscope are driven by the modulating signal voltage from the Model 102A, a linear division of frequencies along the horizontal axis of the oscilloscope display is produced. The response curve may be marked in terms of frequency in order to measure the bandwidth and indicate important frequency points. This can be accomplished by loosely coupling the output of a marker generator to the signal input of the i-f amplifier. Small pips will appear on the oscilloscope screen at the marker generator frequency to indicate the frequency at a particular point on the response curve.

2-31. Phase Locking of Model 102A. In applications where extreme frequency stability is required, the Model 102A can be phase-locked to an external frequency standard. Figure 2-13 shows the equipment arrangement for phase-locked operation. To achieve a lock, the output frequency of the Model 102A is tuned to the frequency of the external frequency standard. When a lock has been achieved, it will be noted that the frequency VERNIER can be tuned for a portion of its range either side of the locked frequency without changing the output frequency of the Model 102A.

2-32. Avoidance and Identification of Harmonics. Careful consideration to the suppression of harmonics has been given in the design of the Model 102A. The extent to which harmonics and other spurious signals are suppressed is typified in Figure 2-14. Harmonics should not normally present a problem in the use of the Model 102A. The direct-reading output frequency indicator provides assurance that equipment being tested will not be tuned inadvertently to a harmonic. A quick visual check to ascertain that the frequency setting of the equipment being tested corresponds to the output frequency indication on the Model 102A is all that is normally required.

2-33. Visual Frequency Response Checks. Automatically leveled output, and its direct-reading output frequency display, are two features of the Model

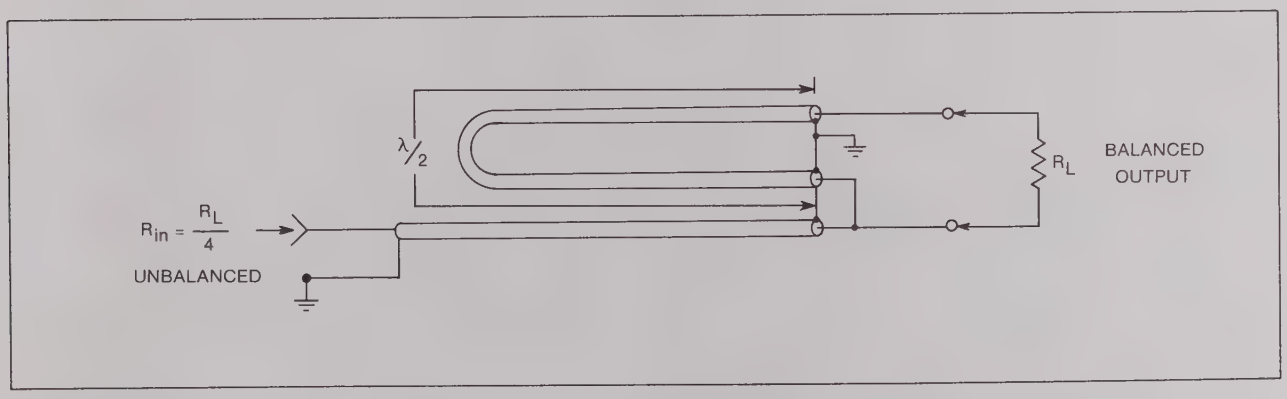


Figure 2-11 Narrowband Response 4:1 Coaxial Balun

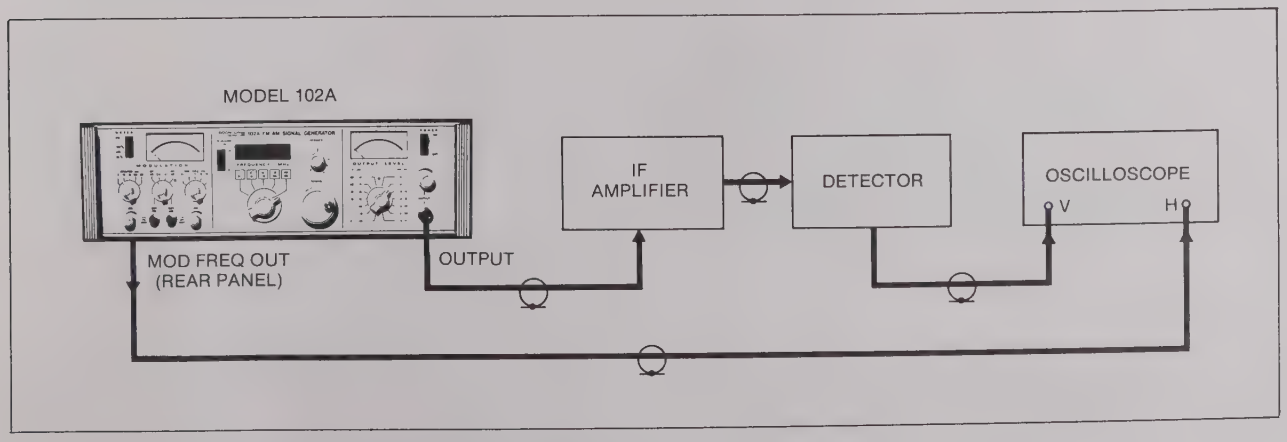


Figure 2-12 IF Response Measurement, Typical Equipment Connection

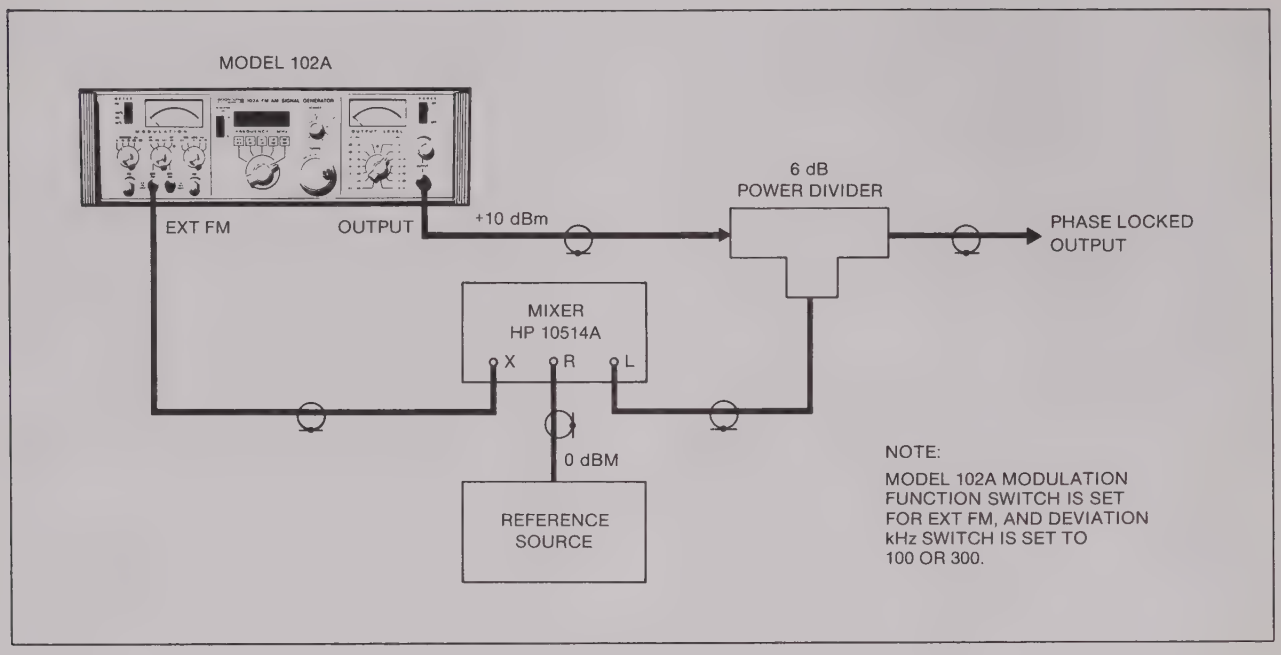


Figure 2-13 Phase Locking of Model 102A, Typical Equipment Connection

102A which make it extremely useful for quick visual checks of the frequency response characteristics of filters, amplifiers, and similar equipment. Figure 2-15 shows a typical equipment arrangement for such an application. Because the output of the Model 102A is automatically leveled, tuning the instrument changes only one test parameter, the output frequency. To perform a quick visual check of response characteristics, the Model 102A is tuned slowly over the frequency range of interest, while the signal level at the output of the device under test is monitored. At points where the signal level deviates from normal, or at points where the signal level reaches predetermined limits, the corresponding frequency can be read directly on the output frequency indicator of the Model 102A.

2-34. EIA Sensitivity Measurement. The Model 102A qualifies in every respect as a standard input signal source for EIA receiver sensitivity measurements. A typical equipment arrangement for such an application is shown in Figure 2-16. Measurement of the minimum usable sensitivity of land-mobile FM communications receivers involves the following steps:

NOTE

EIA Receiver sensitivity measurements should be performed at standard temperature (+20 to +35°C) and standard relative humidity (0 to 90% at +20 to +30°C, 0 to 70% at +30 to +35°C).

a. The equipment is connected as shown in Figure 2-16.

b. The receiver squelch control, if any, is unsquelched to the maximum possible extent.

c. The Model 102A is tuned to the receiver frequency, the modulation controls are adjusted to provide standard test modulation, and the output level is adjusted to 1000 microvolts. Standard test modulation is defined as ± 2/3 of the maximum applicable rated system deviation listed below, at 1 kHz.

Frequency Range	Channel Spacing	Maximum Rated System Deviation
25 to 54 MHz	40 kHz	±15 kHz
25 to 54 MHz	20 kHz	±5 kHz
144 to 174 MHz	60 kHz	±15 kHz
144 to 174 MHz	30 kHz	±5 kHz
400 to 470 MHz	100 kHz	±15 kHz
400 to 470 MHz	50 kHz	±10 kHz

d. The receiver volume control is adjusted to provide rated output.

e. The output level of the Model 102A is adjusted until the ratio of signal plus noise plus distortion to noise plus distortion is 12 dB. At this signal level, the audio output of the receiver should be at least 50% of rated audio output without readjustment of the re-

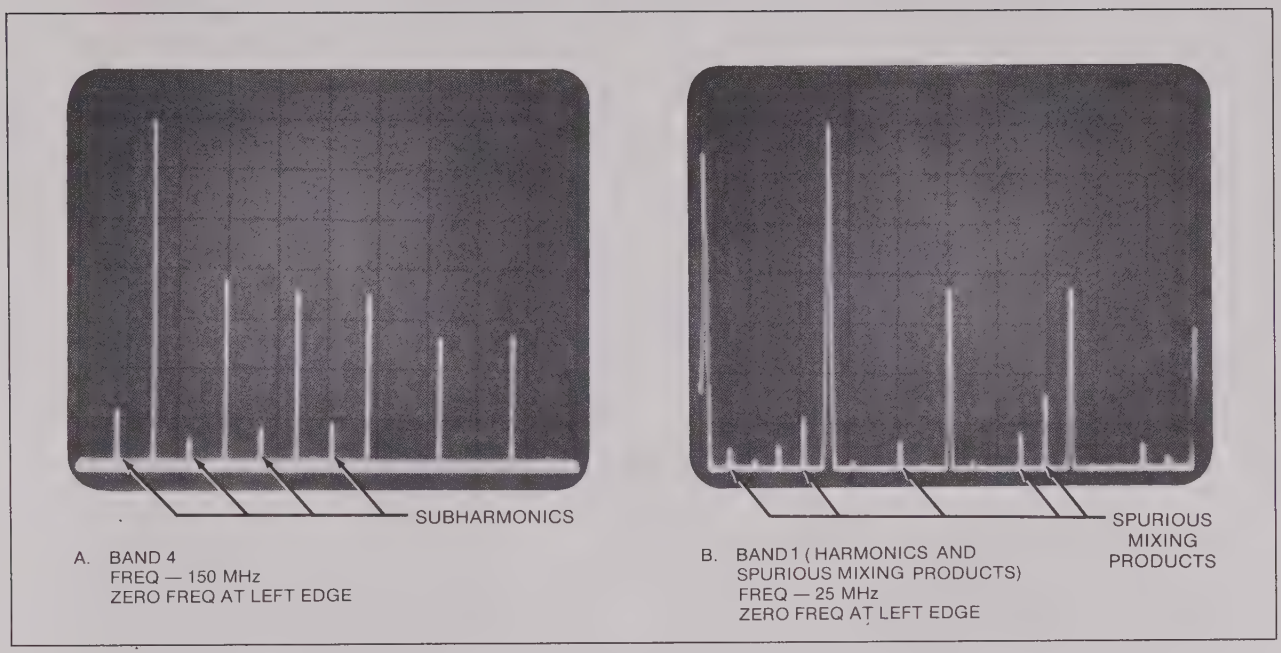

SUBHARMONICS
A. BAND 4
FREQ — 150 MHz
ZERO FREQ AT LEFT EDGE
SPURIOUS MIXING PRODUCTS
B. BAND 1 (HARMONICS AND SPURIOUS MIXING PRODUCTS)
FREQ — 25 MHz
ZERO FREQ AT LEFT EDGE

Figure 2-14 Typical Spectrum Display, Showing Harmonics

ceiver volume control. If the audio output is less than 50% of the rated audio output, increase the output level of the Model 102A until 50% of rated audio output is obtained, and this value of RF signal input is used to specify sensitivity. Minimum usable sensitivity should be as follows:

Band	Microvolts (Open Circuit)
25 to 54 MHz	1.0
144 to 174 MHz	1.5
400 to 470 MHz	2.5

NOTE

Open circuit generator voltage is twice that which is indicated by the 102A output monitor and attenuator. The Model 102A will indicate the open circuit voltage, as defined in the EIA test procedure, if a 6 dB matching pad is inserted between the output of the Model 102A and the 50 ohm input impedance of the receiver.

2-35. MINIMUM PERFORMANCE CHECKS.

2-36. Test Equipment Required. Table 2-2 lists all test equipment required to perform minimum performance checks of the Model 102A.

TABLE 2-2. TEST EQUIPMENT LIST

Amplifier	Hewlett-Packard 465A
Band Pass Filter	f_0 = 10 kHz (see Figure 2-27 for circuit description)
Crystal-Controlled Sources	(37.1 MHz, 70 MHz, 100 MHz, 200 MHz, 450 MHz)
Directional Coupler	Anzac DCG 20-4
Distortion Analyzer	Hewlett-Packard 331A
Double Balanced Mixer	Hewlett-Packard 10514A
FM-AM Signal Generator	Boonton Electronics 102A
Frequency Counter	Systron Donner 6052 (8 digit, option 11 time base)
Frequency Meter	Hewlett-Packard 5210A
Low Pass Filter	Itel (15 kHz)

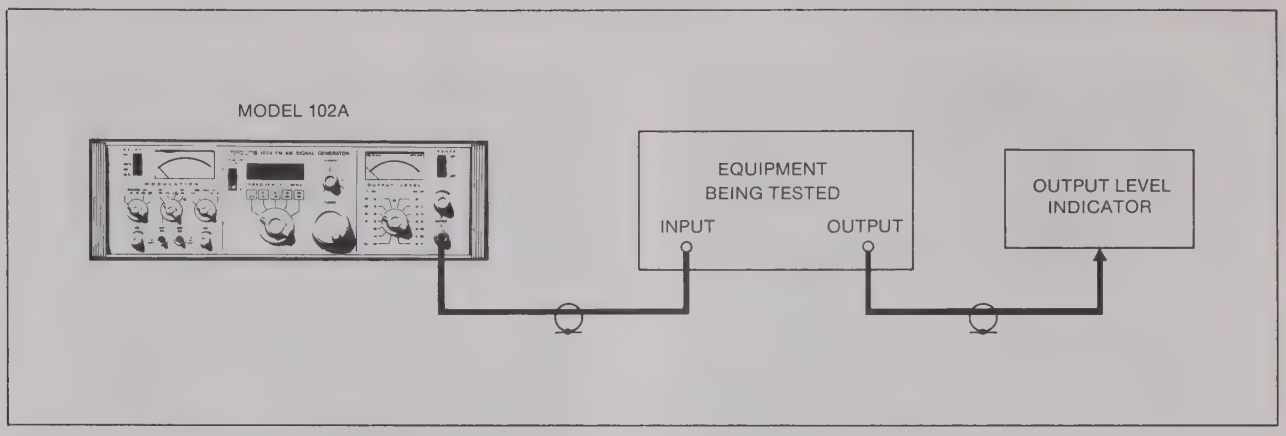


Figure 2-15 Frequency Response Checks, Typical Equipment Connection

TABLE 2-2. TEST EQUIPMENT LIST (Cont)

Microwattmeter	Boonton Electronics 42A
Oscillator	Hewlett-Packard 200CD
Oscilloscope	Tektronix 5103N (5A20N Vertical Amplifier, 5B10N Time Base)
Power Divider	Microlab DA-3FB
Precision Attenuator	AIL 32
Precision Voltage Calibrator	Ballantine 421A
Probe	Tektronix P6060
RF Amplifier	Avantek UTO-502
RF Pickup Loop	See Figure 2-25 for circuit description
Spectrum Analyzer	Hewlett-Packard 141T/8552B/8556A
Spectrum Analyzer	Systron Donner 751B
Step Attenuator	Hewlett-Packard 355D
Strip Chart Recorder	Rustrak Model A
Voltmeter	Boonton Electronics 93A
10 dB Attenuator	Microlab AB-10B
50-Ohm Termination	Boonton Electronics 91-15A

2-37. Frequency Accuracy Check. To check the accuracy of the Model 102A output frequency indicators, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-17.

b. Set the controls of the Model 102A as follows:

Control	Setting
DEVIATION kHz switch	300
MODULATION function switch	EXT
FM control	Fully clockwise
FREQUENCY MHz switch	Band 1 (4.3—37.5)
RESOLUTION kHz switch	0.1
TUNING control	37.1 MHz indication on output frequency indicator
OUTPUT LEVEL attenuator	+10 dBm
OUTPUT control	0 dB indication on OUTPUT LEVEL meter

c. Adjust the oscilloscope controls to obtain a display of the beat frequency input signal from the mixer.

d. Phase lock the Model 102A output frequency to the 37.1 MHz crystal reference frequency by rotating the VERNIER control slowly to the point where the beat frequency signal display on the oscilloscope decreases and abruptly disappears.

e. Using the frequency counter, measure and record the output frequency of the Model 102A.

f. Compare the frequency displayed on the output frequency indicator of the Model 102A with that recorded in preceding step e. *The difference between the two frequencies should not exceed 0.2 kHz.*

g. With the FREQUENCY MHz switch set successively to each of the four remaining bands, the TUNING control adjusted to obtain the output frequency listed below, as appropriate for the band selected, and the appropriate crystal-controlled source connected to the R port of the mixer, repeat steps d through f for each band. *The difference between the two frequency indications should not exceed the values listed below.*

Model 102A Band	Output Frequency	Maximum Frequency Difference
2	37.1 MHz	0.2 kHz
3	70.0 MHz	0.3 kHz
4	200.0 MHz	0.7 kHz
5	450.0 MHz	1.4 kHz

2-38. Frequency Range Check. To check the tuning range of the Model 102A, proceed as follows:

a. Set the MODULATION function switch to CW, the RESOLUTION kHz switch to 10, the FREQUENCY MHz switch to band 1 (4.3—37.5), and the VERNIER control to 0.

b. Rotate the TUNING control to its fully clockwise position and record the display on the output frequency indicator. *The output frequency should be 4.30 MHz or lower.*

c. Rotate the TUNING control to its fully counterclockwise position and record the display on the output frequency indicator. *The output frequency should be 37.50 MHZ or higher.*

d. Using procedures similar to those in steps b and c, record the lowest frequency (fully counterclockwise setting of the TUNING control) and the highest frequency (fully clockwise setting of the TUNING control) obtainable on each of the four upper bands of the Model 102A. *Output frequency limits should be as follows:*

Band	Lowest Frequency	Highest Frequency
2	32.50 MHz or lower	65.00 MHz or higher
3	65.00 MHz or lower	130.00 MHz or higher
4	130.00 MHz or lower	260.00 MHz or higher
5	260.00 MHz or lower	520.00 MHz or higher

2-39. Output Level Accuracy Check. To check output level accuracy, proceed as follows:

a. Connect the power detector of a microwattmeter, Boonton Electronics Model 42A, to the OUTPUT connector of the Model 102A.

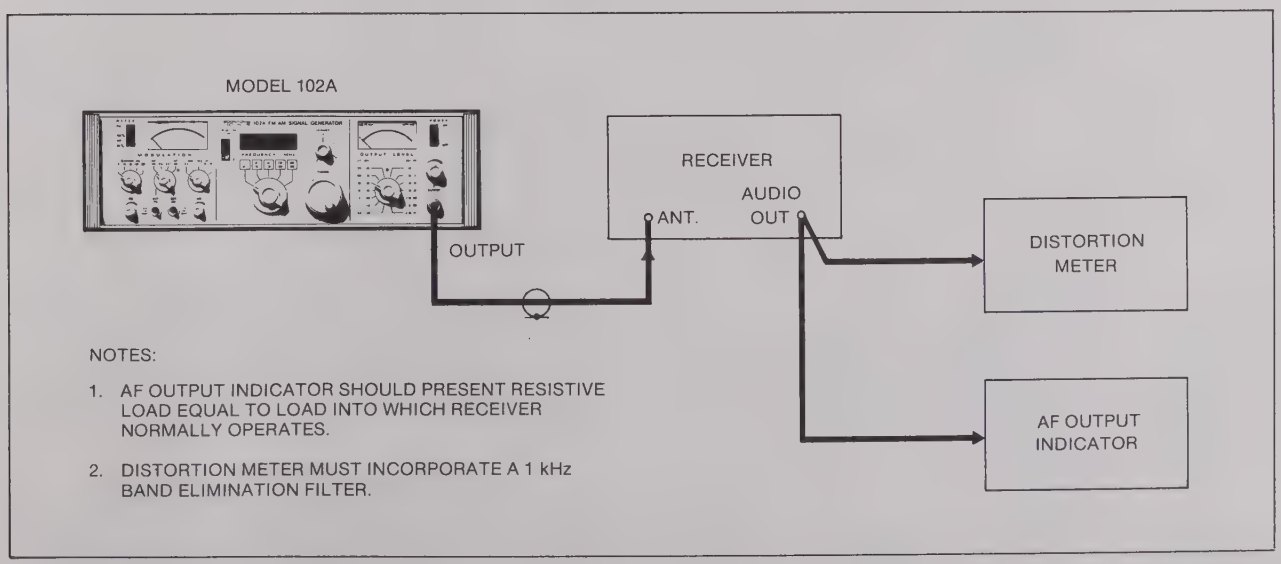


Figure 2-16 EAI Sensitivity Check, Typical Equipment Connection

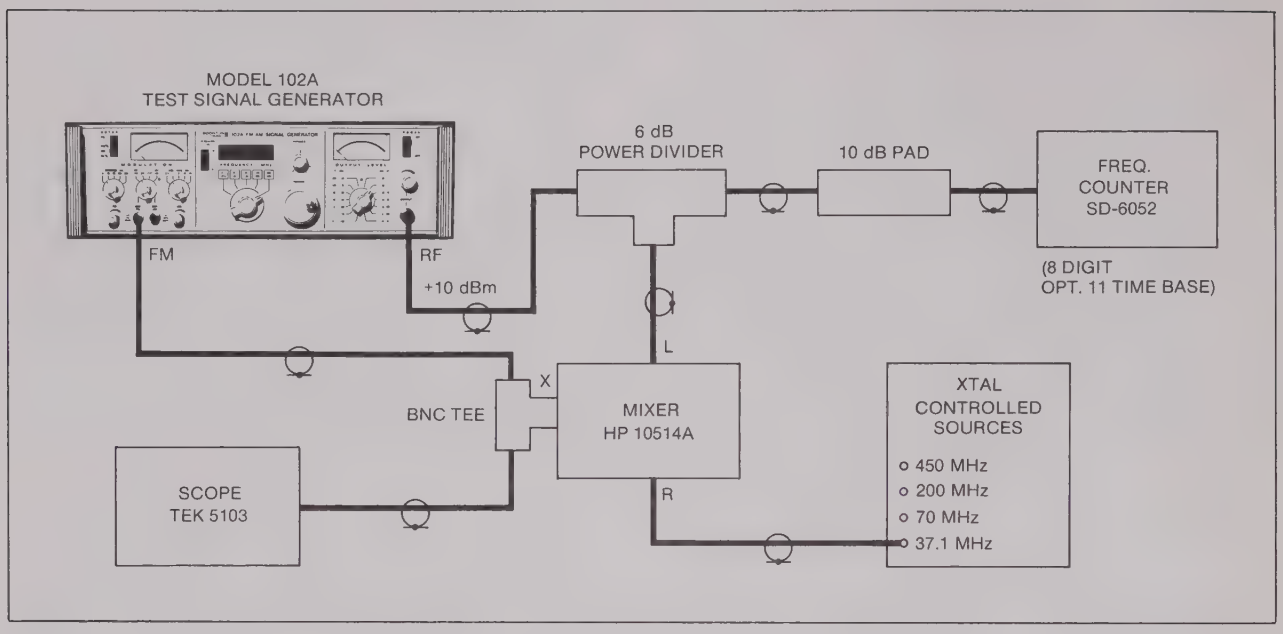


Figure 2-17 Frequency Accuracy Check, Test Setup

b. Set the MODULATION function switch to CW, the FREQUENCY MHz switch to band 1 (4.3—37.5), and the RESOLUTION kHz switch to 10. Using the TUNING control, tune the Model 102A to an output frequency of 5 MHz, as indicated on the output frequency indicator.

c. Set the OUTPUT LEVEL attenuator to 0 dBm. Using the OUTPUT control, position the pointer of the OUTPUT LEVEL meter to 0 dBm on the appropriate bottom scale of the meter.

d. Check the power indication of the microwattmeter. *Indicated power level should be 0 dBm, ±1dBm.*

e. Using the TUNING control, tune the Model 102A successively to each of the check frequencies listed below, and repeat steps c and d at each check frequency. *The power level indication of the microwattmeter should be 0±1 dBm at each of the listed frequencies.*

Check Frequencies

20 MHz	200 MHz	400 MHz
50 MHz	250 MHz	450 MHz
100 MHz	300 MHz	500 MHz
150 MHz	350 MHz	520 MHz

f. Using the FREQUENCY MHz switch and the TUNING control, tune the Model 102A to an output frequency of 100 MHz, as indicated on the output frequency indicator. Using the OUTPUT control, adjust the output level in 2.0 dB decrements from -2.0 to -10.0 dBm, as indicated on the lowest scale of the OUTPUT LEVEL meter. At each point, note the power level indication of the microwattmeter. *The microwattmeter indication should be within ±1.0 dB of the microwattmeter indication at each point.*

g. Repeat step f with the Model 102A tuned to an output frequency of 500 MHz. *The microwattmeter indication should be within ±1.0 dB of the OUTPUT LEVEL meter indication at each power level check point.*

h. Connect the Model 102A and test equipment as shown in Figure 2-18. Set the controls of the test Model 102A and the reference Model 102A as shown in Table 2-3.

i. Set the precision attenuator to the point previously calibrated to produce a 40.0 dB overall loss through the calibrated test fixture.

j. Set the spectrum analyzer controls for the linear mode of operation and to provide a display of the 30 MHz i-f signal. Using the i-f and video gain controls of the spectrum analyzer, align the peak of the 30 MHz i-f signal with the 1.0 graticule of the spectrum analyzer display.

k. Increase the attenuation of the precision attenuator by 60.00 dB. Set the OUTPUT LEVEL attenuator of the test Model 102A to 0 dBm. Note the amplitude of the 30 MHz i-f signal on the spectrum analyzer display. *The amplitude should be 0.93 to 1.07.*

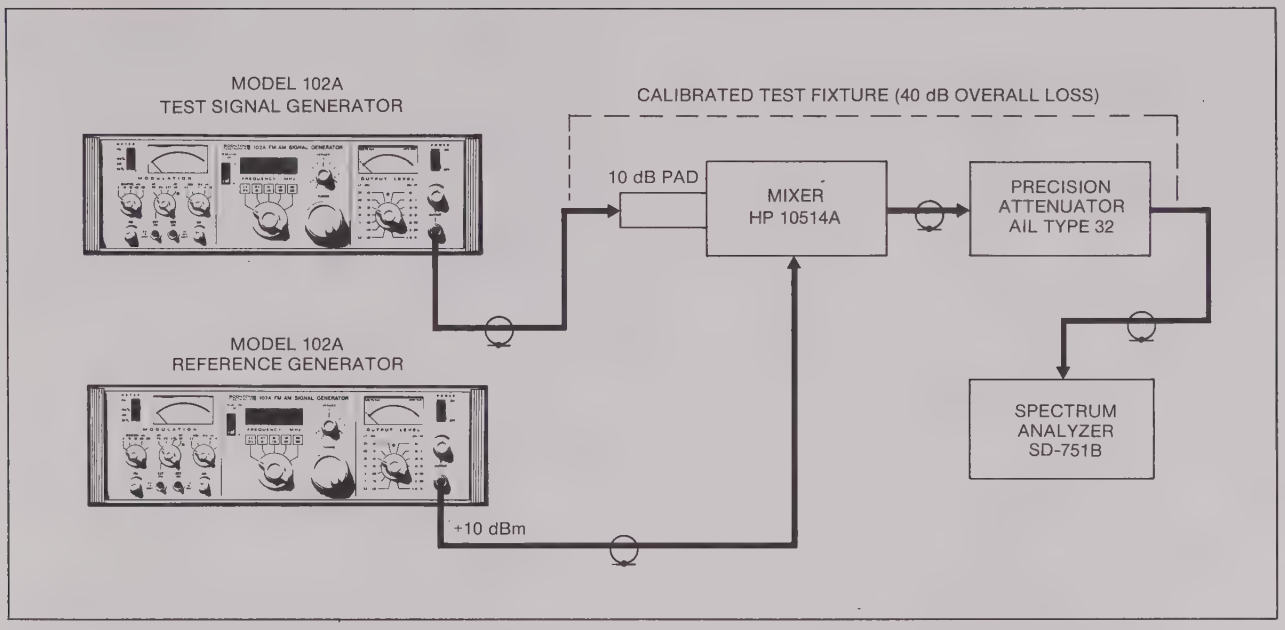


Figure 2-18 Output Level Accuracy Check, Test Setup

TABLE 2-3. CONTROL SETTINGS FOR OUTPUT LEVEL ACCURACY CHECK

Control	Test Model 102A	Reference Model 102A
MODULATION function switch	CW	CW
FREQUENCY MHz switch	Band 5 (260—520)	Band 5 (260—520)
RESOLUTION kHz switch	10	10
TUNING control	450.0 MHz on output frequency indicator	480.0 MHz on output frequency indicator
OUTPUT LEVEL attenuator	-60 dBm	±10 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter	0 dB on OUTPUT LEVEL meter

2-40. Output Leveling Check. To check the automatic leveling circuits of the Model 102A, proceed as follows:

a. Connect the power detector of a microwattmeter, Boonton Electronics Model 42A, to the OUTPUT connector of the Model 102A.

b. Set the MODULATION function switch to CW, the FREQUENCY MHz switch to band 1 (4.3–37.5), and the OUTPUT LEVEL attenuator to +10 dBm. Using the OUTPUT control, position the pointer of the OUTPUT LEVEL meter to 0 dBm on the lowest scale of the meter.

c. Using the TUNING control, tune the Model 102A slowly from 4.3 MHz to 37.5 MHz, and record the maximum and minimum indications of the microwattmeter. *The difference between the maximum and minimum power level indications should not exceed 1.0 dB.*

d. Position the pointer of the OUTPUT LEVEL meter to -10 dBm on the bottom scale, using the OUTPUT control, and repeat step c. *The difference between the maximum and minimum power level indications should not exceed 1.0 dB.*

e. Set the FREQUENCY MHz switch successively to each of bands 2 through 5 and repeat steps c and d

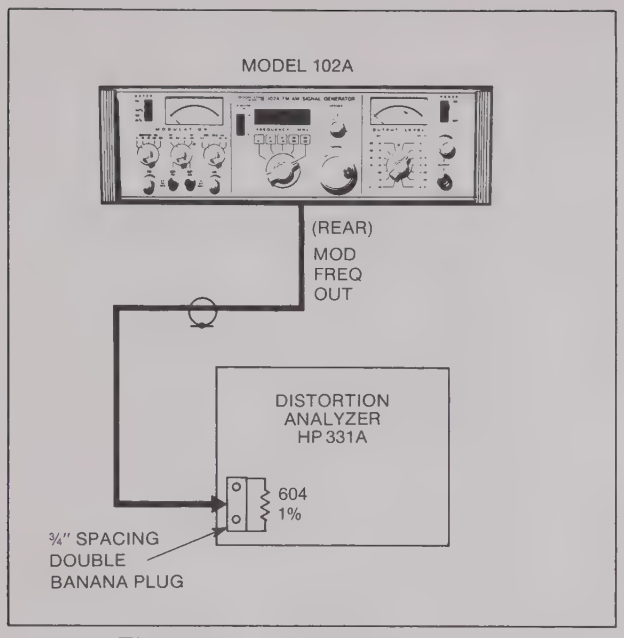


Figure 2-19 Modulation Oscillator Output Check, Test Setup

for each band, tuning the Model 102A over the following frequency ranges:

Band	Tuning Range
3	32.5 to 65.0 MHz
3	65.0 to 130.0 MHz
4	130.0 to 260.0 MHz
5	260.0 to 520.0 MHz

The difference between the maximum and minimum power level indications on the microwattmeter should not exceed 1.0 dB on any band.

2-41. Spurious Output Check. To check for spurious output signals from the Model 102A, proceed as follows:

a. Set the FREQUENCY MHz switch to band 1 (4.3—37.5), the MODULATION function switch to CW, and the OUTPUT LEVEL attenuator to +10 dBm. Using the OUTPUT control, position the pointer of the output LEVEL meter to 0 dBm on the lowest scale of the meter.

b. On a spectrum analyzer, Systron Donner SD-751, set in 20 dB of RF attenuation, and connect the spectrum analyzer to the OUTPUT connector of the Model 102A. Adjust the i-f bandwidth of the spectrum analyzer to 100 kHz, the scan width to 10 MHz per centimeter, and the i-f gain controls to provide a display with the main r-f signal peak aligned with the -10 dB graticule.

c. Using the TUNING control, tune the Model 102A slowly from 4.3 MHz to 37.5 MHz, noting all signals whose amplitude is within 40 dB of the desired output signal on the spectrum analyzer. *All spurious signal amplitudes should be at least 30 dB below the main output signal amplitude. Ascertain that these signals are either harmonics of the main output signal (related by an integer) or spurious mixing products.* Spurious mixing products will appear as signals which move at a rate equal to the rate of movement of the main output signal as the TUNING control is rotated, or at a rate equal to integral multiples of the main output signal rate.

d. Set the FREQUENCY MHz switch on the Model 102A to band 2 (32.5—65). Set the scan width of the spectrum analyzer to 30 MHz per centimeter, and adjust the i-f gain controls to obtain an output signal display with its peak aligned with the -10 dB graticule on the spectrum analyzer.

e. Repeat step c, except tune the Model 102A slowly from 32.5 MHz to 65 MHz. *Ascertain that all signals less than 40 dB below the main output are harmonics. These should be at least 30 dB below the main output.*

f. Set the FREQUENCY MHz switch on the Model 102A to bands 3, 4, and 5 in sequence. Set the scan width of the spectrum analyzer to 30 MHz per centimeter, 50 MHz per centimeter, and 50 MHz per centimeter, respectively, and adjust the i-f gain controls as in step d.

g. Repeat step c on each of bands 3, 4, and 5, except tune the Model 102A over the following frequency ranges:

Band	Tuning Range
3	65 MHz to 130 MHz
4	130 MHz to 260 MHz
5	260 MHz to 520 MHz

All test results should be the same as in step e.

h. Using the OUTPUT control on the Model 102A, position the pointer of the OUTPUT LEVEL meter to -10 dBm on the bottom scale. Repeat steps b through g. *All test requirements are the same.*

2-42. Modulation Oscillator Output Check. To check the signal amplitude of the internally generated modulation signals, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-19.

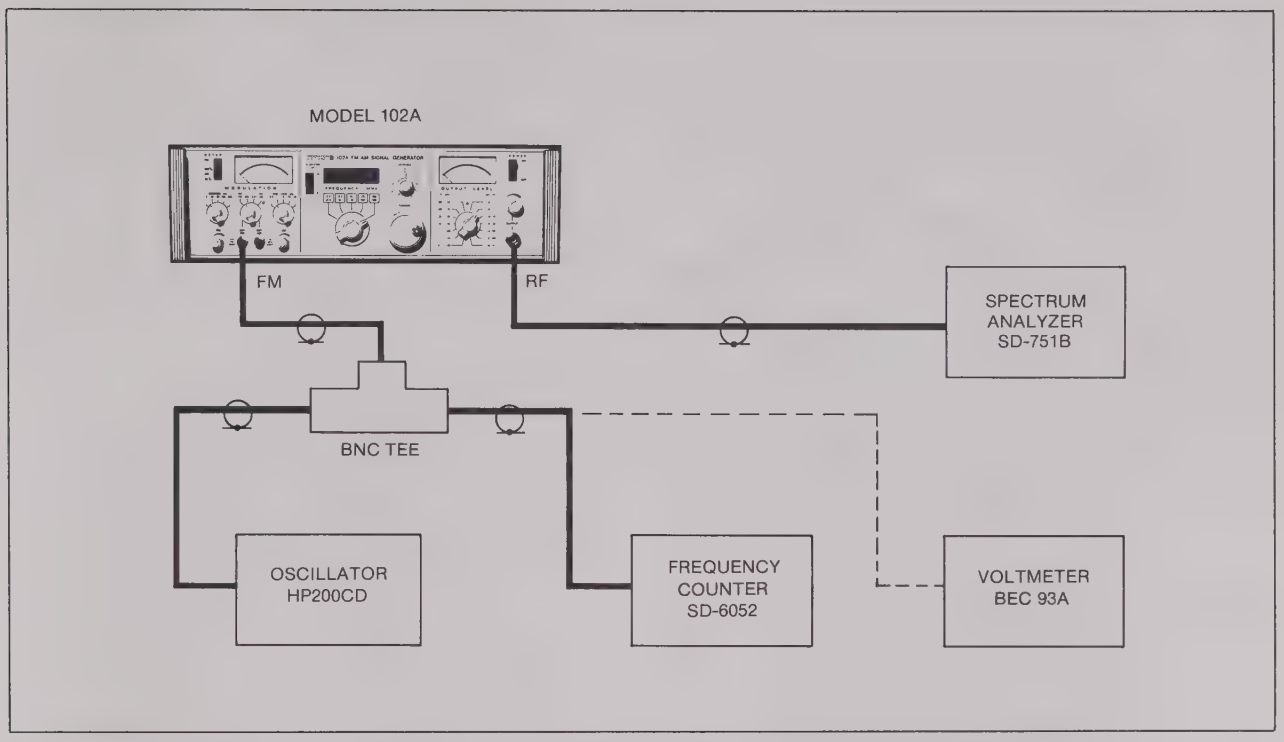


Figure 2-20 FM Sensitivity Check, Test Setup

b. Set the MODULATION function switch to INT FM. Set the function switch on the distortion analyzer to the voltmeter position.

c. Set the MOD FREQ kHz switch on the Model 102A to 0.4, 1, 3, 10, and 19, in sequence. Note the voltage indication on the distortion analyzer meter for each switch position. *The voltage should be 1.0 volt rms minimum in each case.*

2-43. Modulation Frequency Accuracy Check. To check the frequency accuracy of the internally generated modulation signals, proceed as follows:

a. Connect a frequency counter, Systron Donner SD-6052, to the MOD FREQ OUT connector on the rear panel of the Model 102A.

b. Set the MODULATION function switch to INT FM.

c. Set the MOD FREQ kHz switch to each of its five positions in sequence, and measure the frequency of the modulation signal for each switch setting, using the frequency counter. *Modulation frequencies should be within the limits specified below.*

Switch Position	Modulation Frequency Limits
0.4	0.388 to 0.412 kHz
1	0.970 to 1.030 kHz
3	2.910 to 3.090 kHz
10	9.700 to 10.300 kHz
19	18.430 to 19.570 kHz

2-44. Modulation Oscillator Distortion Check. To check distortion of the internal modulation oscillator, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-19.

b. Set the MODULATION function switch to INT FM. Set the function switch on the distortion analyzer to the set level position.

c. Set the MOD FREQ kHz switch to each of its five positions in sequence. At each switch position, measure the distortion with the distortion analyzer. *Distortion should not exceed 0.3% THD.*

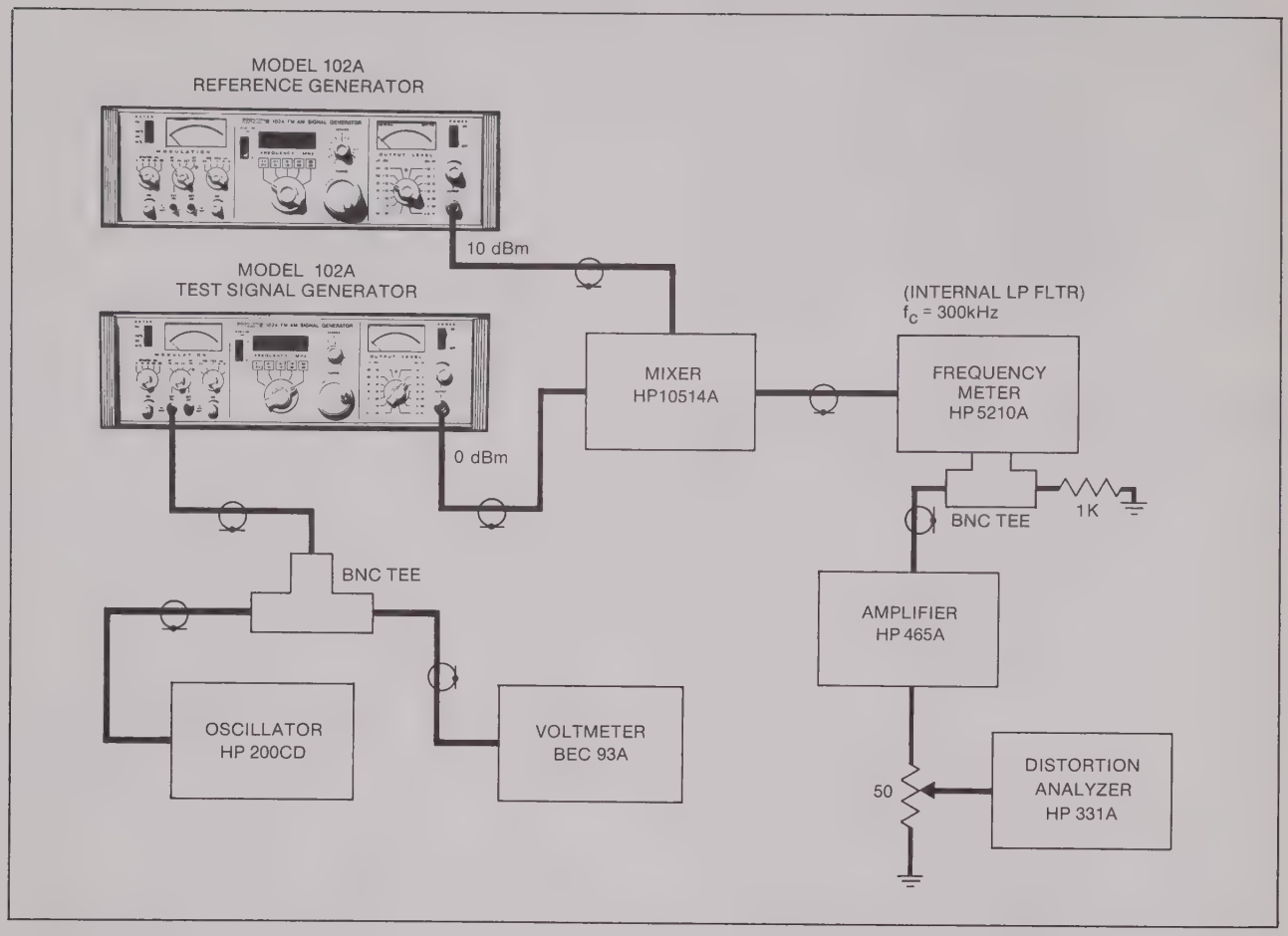


Figure 2-21 FM Bandwidth and Distortion Checks, Test Setup

2-45. FM Measurements. This paragraph provides instructions for measurement of the FM characteristics of the Model 102A. Proceed from one check to the next, without disturbing test setups or control settings, unless specifically directed otherwise.

a. **FM Sensitivity Check.** To check FM sensitivity, proceed as follows:

1. Connect the Model 102A and test equipment as shown in Figure 2-20.

2. Set the controls on the Model 102A as follows:

Control	Position
DEVIATION kHz switch	100
MODULATION function switch	EXT
FREQUENCY MHz switch	Band 3 (65-130)
TUNING control	100.00 MHz as indicated on output frequency indicator
OUTPUT LEVEL attenuator	0 dBm
OUTPUT control	0 dB as indicated on OUTPUT LEVEL meter
FM control	Fully counterclockwise

3. Adjust the spectrum analyzer scan width to 30 kHz per centimeter and the i-f bandwidth to 1 kHz. Adjust the i-f gain controls as required to obtain a display in which the peak of the carrier signal is aligned with the -10 dB graticule. Center the carrier signal on the spectrum analyzer display.

4. Set the oscillator frequency to 41.58 kHz, using the frequency counter to check the frequency. Adjust the FM control on the Model 102A to the fully clockwise position.

5. Set the oscillator amplitude control to minimum, then advance it slowly clockwise until the amplitude of the carrier in the spectrum analyzer display drops to a minimum or null, at least below -40 dB. Using the frequency counter, ascertain that the oscillator frequency is still 41.58 kHz. The actual FM deviation of the Model 102A is now 100 kHz ± 1 kHz.

6. Replace the frequency counter in the test setup with the voltmeter, and measure the oscillator output voltage. *The voltage should be 3.0 volts rms or less.*

b. **FM Bandwidth Check.** Upon completion of the FM sensitivity check, perform the following FM bandwidth check without disturbing any control settings of the Model 102A or the test equipment:

1. Connect the test Model 102A and test equipment as shown in Figure 2-21.

2. Set the controls of the *reference* Model 102A as follows:

Control	Position
FREQUENCY MHz	Band 3 (65—130)
TUNING control	108.0 MHz on output frequency indicator
MODULATION function switch	CW
OUTPUT LEVEL attenuator	+10 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter

3. Set the range switch of the frequency meter to the 10 MHz position.

4. Set the function switch of the distortion analyzer to the voltmeter position and the meter range switch to the 1 volt position. Adjust the 50 ohm potentiometer as required to obtain a 0.80 volt rms indication on the distortion analyzer meter. (The distortion analyzer meter is now calibrated as a frequency deviation meter, with a scale factor of 125 kHz per volt rms.

5. Set the oscillator frequency to 10 kHz and adjust the amplitude control as required to obtain a 6.00 volt rms indication on the voltmeter. Adjust the FM control on the test Model 102A in a counterclockwise direction until the distortion analyzer meter again indicates 0.80 volt rms.

6. Set the oscillator frequency to 200 kHz and adjust the amplitude control as required to obtain an indication of 0.80 volt rms on the distortion analyzer meter. Note the oscillator output voltage indication on the voltmeter. *The oscillator output voltage should be 5.65 to 8.45 volts rms.*

c. **FM Accuracy Check.** Without disturbing the test setup or any control settings, except as specified, check the FM accuracy of the Model 102A as follows:

1. Set the oscillator frequency to 10 kHz. Set the METER switch on the *test* Model 102A to FM.

2. Using the FM control on the *test* Model 102A, position the pointer of the MODULATION meter to exactly 100. Check the voltage indication on the distortion analyzer meter. *The voltage should be 0.72 to 0.88 volt rms.*

3. Set the oscillator frequency to 20 kHz and repeat step 2. *The voltage indication on the distortion analyzer meter should be 0.72 to 0.88 volt rms.*

4. Set the oscillator frequency to 200 kHz and repeat step 2. *The voltage indication on the distortion analyzer meter should be 0.68 to 0.92 volt rms.*

5. Set the oscillator frequency to 10 kHz. Set the FREQUENCY MHz switch on the *test* Model 102A and the *reference* Model 102A to band 2, (32.5—65). Using the TUNING controls of the respective instruments, tune the *test* Model 102A to 32.5 MHz, and the *reference* Model 102A to 40.5 MHz, as indicated on the respective output frequency indicators. Using the FM control on the *test* Model 102A, position the pointer of the MODULATION meter to exactly 100. Observe the voltage indication on the distortion analyzer meter. *The voltage indication should be 0.72 to 0.88 volt rms.*

6. Set the output frequencies of the *test* Model 102A and the *reference* Model 102A to the following frequencies, in sequence.

Test Model 102A	Reference Model 102A
35 MHz	43 MHz
40 MHz	48 MHz
45 MHz	53 MHz
50 MHz	58 MHz
55 MHz	63 MHz
60 MHz	68 MHz
65 MHz	73 MHz

At each of the test frequencies, position the pointer of the MODULATION meter on the *test* Model 102A to exactly 100, using the FM control, and observe the voltage indication on the distortion analyzer meter. *The voltage indication should be 0.72 to 0.88 volt rms in each instance.*

d. **Range Ratio Check.** To check the FM range ratios, proceed as follows:

1. Connect the output of a precision voltage calibrator, Ballantine Model 421A, to the EXT FM connector of the Model 102A. Connect an rms voltmeter, Boonton Electronics Model 93A, to the FM terminal at the top left side of the VFO housing in the Model 102A. (The FM terminal has a shielded wire soldered to it.)

2. Set the Model 102A controls as follows:

Control	Position
MODULATION function switch	EXT
DEVIATION kHz switch	300
FREQUENCY MHz switch	Band 1 (4.3—37.5)

3. Set the full scale switch of the rms voltmeter to the 10 millivolt position. Set the mode switch on the prevision voltage calibrator to the 1 kHz rms position, the output to 10.000 millivolts, and the range switch to 100 millivolts.

4. Using the FM control on the Model 102A, position the pointer of the rms voltmeter to exactly 5.00 millivolts.

5. Set the FREQUENCY MHz switch on the Model 102A to each of the four upper bands in sequence. At each switch position, adjust the output of the precision voltage calibrator as required to maintain the 5.00 millivolt indication on the rms voltmeter, and record the output voltage of the precision voltage calibrator. *The output voltage required for a 5.00 millivolt indication on the rms voltmeter should be as follows:*

Band	Output Voltage Limits
2	9.80 to 10.20 millivolts
3	19.60 to 20.40 millivolts
4	39.20 to 40.80 millivolts
5	78.40 to 81.60 millivolts

6. Set the FREQUENCY MHz switch on the Model 102A to band 1 (4.3—37.5). Readjust the output voltage of the precision voltage calibrator to 10.00 millivolts. Set the DEVIATION kHz switch on the Model 102A to each of its four lower settings in sequence. At each switch setting, adjust the output voltage of the precision voltage calibrator as required to maintain a 5.00 millivolt indication on the rms voltmeter, and record the output voltage of the precision voltage calibrator. *The output voltage required for a 5.00 millivolt indication on the rms voltmeter should be as follows:*

DEVIATION kHz Switch Setting	Output Voltage Limits
100	31.00 to 32.20 millivolts
30	98.00 to 102.00 millivolts
10	310.00 to 322.00 millivolts
3	980.00 to 1020.00 millivolts

e. **Meter Linearity Check.** To check the FM linearity of the MODULATION meter, proceed as follows:

1. Connect a precision voltage calibrator, Ballantine Model 421A, to the EXT FM connector of the Model 102A. Set the precision voltage calibrator mode switch to the 1 kHz p-p position, the range switch to the 10 volt position, and the output to 10.00 volts.

2. Set the controls of the Model 102A as follows:

Control	Position
MODULATION function switch	EXT
DEVIATION kHz switch	100
METER switch	FM
FREQUENCY MHz switch	Band 3 (65—130)

3. Using the FM control on the Model 102A, position the pointer of the MODULATION meter to exactly 100.

4. Reduce the output voltage of the precision voltage calibrator as required to reduce the indication on the MODULATION meter in 10-division decrements. Record the output voltage of the precision voltage calibrator at each point. *The output voltage should be as follows:*

MODULATION Meter Indication	Output Voltage Limits
90	8.80 to 9.20 volts
80	7.80 to 8.20 volts
70	6.80 to 7.20 volts
60	5.80 to 6.20 volts
50	4.80 to 5.20 volts
40	3.80 to 4.20 volts
30	2.80 to 3.20 volts
20	1.80 to 2.20 volts
10	0.80 to 1.20 volts

f. **FM Distortion Check.** To check FM distortion, proceed as follows:

1. Connect the test Model 102A and test equipment as shown in Figure 2-21.

2. Set the controls of the test Model 102A and the reference Model 102A as shown in Table 2-4.

3. Set the oscillator controls to provide an output frequency of 10 kHz. Using the amplitude control of the oscillator, position the pointer of the MODULATION meter on the *test* Model 102A to exactly 100. Measure the distortion with the distortion analyzer. *Distortion should not exceed 2.0% THD.*

4. Set the oscillator controls to provide an output frequency of 200 KHz. If necessary, readjust the amplitude control on the oscillator to maintain the MODULATION meter indication of 100 on the *test* Model 102A. Measure the distortion with the distortion analyzer. *Distortion should not exceed 2.0% THD.*

5. Repeat step 4 with the *test* Model 102A and the *reference* Model 102A tuned in sequence to each of the following frequencies:

Test Model 102A	Reference Model 102A
35 MHz	43 MHz
40 MHz	48 MHz
45 MHz	53 MHz
50 MHz	58 MHz
55 MHz	63 MHz
60 MHz	68 MHz
65 MHz	73 MHz

Distortion should not exceed 2.0% THD.

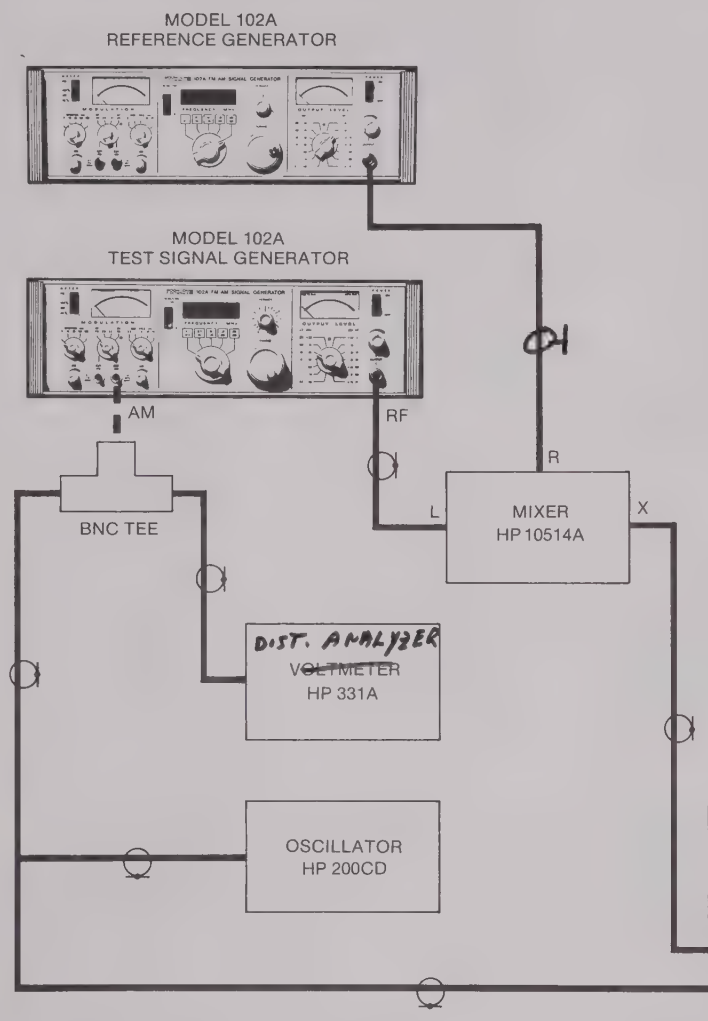
TABLE 2-4. CONTROL SETTINGS FOR FM DISTORTION CHECK

Control	Test Model 102A	Reference Model 102A
DEVIATION kHz switch	100	(Not applicable)
MODULATION function switch	EXT	CW
FREQUENCY MHz switch	Band 2 (32.5—65)	Band 2 (32.5—65)
TUNING control	32.5 MHz on output frequency indicator	40.5 on output frequency indicator
OUTPUT LEVEL attenuator	0 dBm	+10 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter	0 dB on OUTPUT LEVEL meter
FM control	Fully clockwise	(Not applicable)
METER switch	FM	(Not applicable)

2-46. AM Measurements. This paragraph provides instructions for measurement of AM characteristics of the Model 102A. Proceed from one AM check to the next without changing the test setup or disturbing control settings unless specifically directed otherwise.

a. **AM Sensitivity Check.** To check AM sensitivity, proceed as follows:

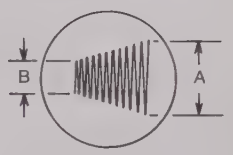
1. Connect the test Model 102A and test equipment as shown in Figure 2-22.



% AM BY TRAPEZOID METHOD

A = 8 DIV. **% AM = $\frac{A-B}{A+B} \times 100$**

B	% AM	B	%AM	B	%AM
7.0	6.7	4.5	28.0	2.0	60.0
6.9	7.4	4.4	29.0	1-9	61.6
6.8	8.1	4.3	30.1	1.8	63.3
6.7	8.8	4.2	31.1	1.7	65.0
6.6	9.6	4.1	32.2	1.6	66.7
6.5	10.3	4.0	33.3	1.5	68.4
6.4	11.1	3.9	34.4	1.4	70.1
6.3	11.9	3.8	35.6	1.3	72.0
6.2	12.7	3.7	36.8	1.2	73.9
6.1	13.5	3.6	38.0	1.1	75.8
6.0	14.3	3.5	39.1	1.0	77.7
5.9	15.1	3.4	40.3	0.9	79.8
5.8	15.9	3.3	41.5	0.8	81.8
5.7	16.8	3.2	42.8	0.7	83.9
5.6	17.7	3.1	44.1	0.6	86.1
5.5	18.5	3.0	45.5	0.5	88.2
5.4	19.4	2.9	46.8	0.4	90.5
5.3	20.3	2.8	48.1	0.3	92.8
5.2	21.2	2.7	49.5	0.2	95.1
5.1	22.1	2.6	51.0	0.1	97.5
5.0	23.1	2.5	52.5		
4.9	24.0	2.4	53.9		
4.8	25.0	2.3	55.4		
4.7	26.0	2.2	56.9		
4.6	27.0	2.1	58.4		



$\%AM = \frac{A-B}{A+B} \times 100$

Figure 2-22 AM Sensitivity Check, Test Setup

2. Set the controls of the *test* Model 102A and the *reference* Model 102A per Table 2-5.

3. Set the function switch of the distortion analyzer to the voltmeter position, and the range switch to the 1 volt position.

4. Set the oscillator controls to provide an output frequency of 1 kHz. Adjust the amplitude control of the oscillator to produce a trapezoid of 8 divisions (dimension A, Figure 2-22) by 4.3 divisions (dimension B) on the oscilloscope. This corresponds to 30% AM. Observe the voltage indication on the distortion analyzer meter. *The voltage should not exceed 1.0 volt rms.*

b. **AM Bandwidth Check.** Upon completion of the AM sensitivity check, perform an AM bandwidth check as follows:

1. Adjust the amplitude control on the oscillator as required to produce a 2.00 volt rms indication on the distortion analyzer meter. Adjust the AM control on the *test* Model 102A as required to produce a 30% AM trapezoid (8 divisions by 4.3 divisions) on the oscilloscope.

2. Set the oscillator frequency controls to provide an output frequency of 20 kHz. Adjust the oscillator amplitude control to produce the 30% AM trapezoid (8 divisions by 4.3 divisions) on the oscilloscope. Observe the voltage indication on the distortion analyzer meter. *The voltage should be 1.90 to 2.50 volts rms.*

c. **AM Accuracy Check.** When the AM bandwidth check has been completed, check AM accuracy as follows:

TABLE 2-5. CONTROL SETTINGS FOR AM SENSITIVITY CHECK

Control	Test Model 102A	Reference Model 102A
MODULATION function switch	EXT	CW
FREQUENCY MHz switch	Band 3 (65—130)	Band 3 (65—130)
TUNING control	100.0 MHz on output frequency indicator	100.2 on output frequency indicator
OUTPUT LEVEL attenuator	-10 dBm	+10 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter	0 dB on OUTPUT LEVEL meter
AM control	Fully clockwise	(Not applicable)
METER switch	100% AM	(Not applicable)

1. Set the METER switch on the *test* Model 102A to 30% AM. Set the oscillator frequency controls to provide a 1 kHz output frequency. Adjust the oscillator amplitude control as required to position the pointer of the MODULATION meter on the *test* Model 102A to exactly 30 on the lower scale. Adjust the vertical gain on the oscilloscope as required to produce a trapezoid with an A amplitude (Figure 2-22) of 8 divisions. Measure and record the B dimension of the trapezoid. Calculate the actual percentage of AM, using the formula given in Figure 2-22. *The actual percentage of AM should be 27.0 to 33.0%.*

2. Set the METER switch on the *test* Model 102A to 100% AM and observe the percentage of AM, as indicated on the top scale of the meter. *The meter indication should be 29.0 to 31.0%.*

3. Adjust the OUTPUT control of the *test* Model 102A as required to position the pointer of the OUTPUT LEVEL meter to -10 dBm. Repeat step 1. *The actual percentage of AM should be 27.0 to 33.0%.*

4. Using the amplitude control on the oscillator, position the pointer of the MODULATION meter on the *test* Model 102A to exactly 50 on the upper scale. Measure the A and B dimensions of the trapezoid displayed on the oscilloscope and calculate the actual percentage of AM. *The actual percentage of AM should be 47.0 to 53.0%.*

5. Using the OUTPUT control on the *test* Model 102A, position the pointer of the OUTPUT LEVEL meter to 0 dB. Repeat step 4. *The actual percentage of AM should be 47.0 to 53.0%.*

6. Tune the *test* Model 102A and the *reference* Model 102A to each of the frequencies listed below, in sequence. Using the OUTPUT controls, maintain an indication of 0 dB on the OUTPUT LEVEL meter of each instrument. Repeat step 4 for each of the listed frequencies.

Test Model 102A	Reference Model 102A
50.0 MHz	50.2 MHz
150.0 MHz	150.2 MHz
200.0 MHz	200.2 MHz
250.0 MHz	250.2 MHz
300.0 MHz	300.2 MHz
350.0 MHz	350.2 MHz
400.0 MHz	400.2 MHz
450.0 MHz	450.2 MHz
500.0 MHz	500.2 MHz
520.0 MHz	520.2 MHz

The actual percentage of AM should be 47.0 to 53.0% at each output frequency.

d. **AM Distortion Check.** Check AM distortion as follows:

1. Set the controls of a distortion analyzer, Hewlett-Packard Model 331A, for distortion measurement of a 1 kHz signal. Using a probe, Tektronix Model P6060, connect the input terminals of the distortion analyzer to the junction of resisters R623 and R626 on the output amplifier and modulator circuit board of the Model 102A.

NOTE

If option 03 is incorporated in the Model 102A, connect the distortion analyzer directly to the DET AM OUT connector on the rear panel of the Model 102A.

2. Set the controls of the Model 102A as follows:

Control	Position
MODULATION function switch	INT AM
MOD FREQ kHz switch	1
METER switch	100% AM
AM control	30% indication on MODULATION meter
FREQUENCY MHz switch	Band 1 (4.3—37.5)
TUNING control	20.00 MHz on output frequency indicator
OUTPUT LEVEL attenuator	0 dBm

3. Using the OUTPUT control of the Model 102A, position the pointer of the OUTPUT LEVEL meter to 0 dB. Measure the distortion with the distortion analyzer. *Distortion should not exceed 1.0% THD.*

4. Using the OUTPUT control of the Model 102A, position the pointer of the OUTPUT LEVEL meter to -10 dBm, and measure the distortion. *Distortion should not exceed 1.0% THD.*

5. Using the AM control on the Model 102A, position the pointer of the MODULATION meter to 70 on the top scale. Measure the distortion with the distortion analyzer. *Distortion should not exceed 2.0% THD.*

6. Using the OUTPUT control on the Model 102A, position the pointer of the OUTPUT LEVEL meter to 0 dB, and measure the distortion. *Distortion should not exceed 2.0% THD.*

7. Using the TUNING control, tune the Model 102A to each of the following output frequencies in sequence, and repeat steps 3 through 6 at each output frequency:

Output Frequencies

100.0 MHz	400.0 MHz
200.0 MHz	450.0 MHz
300.0 MHz	520.0 MHz
350.0 MHz	

Distortion at each of the listed output frequencies should not exceed that specified in steps 3 through 6.

2-47. Incidental AM With FM Check. To check incidental AM, proceed as follows:

a. Using a probe, Tektronix Model P6060, connect the vertical input of an oscilloscope, Tektronix Model 5103N, to the junction of resistors R623 and R626 on the output amplifier and modulator circuit board of the Model 102A.

NOTE

If option 03 is installed in the Model 103A, connect the oscilloscope directly to the DET AM OUT connector on the rear panel of the Model 102A.

b. Set the controls on the Model 102A as follows:

Control	Position
MODULATION function switch	INT AM
MOD FREQ kHz switch	1
METER switch	30% AM
AM control	5% AM on MODULATION meter
OUTPUT LEVEL attenuator	0 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter
DEVIATION kHz switch	100

c. With the oscilloscope vertical attenuator set at 20 mV per division, adjust the vertical gain control of the oscilloscope as required to obtain a 5 division, peak-to-peak, display of the demodulated 1 kHz signal. Then, set the oscilloscope vertical attenuator to 2 mV per

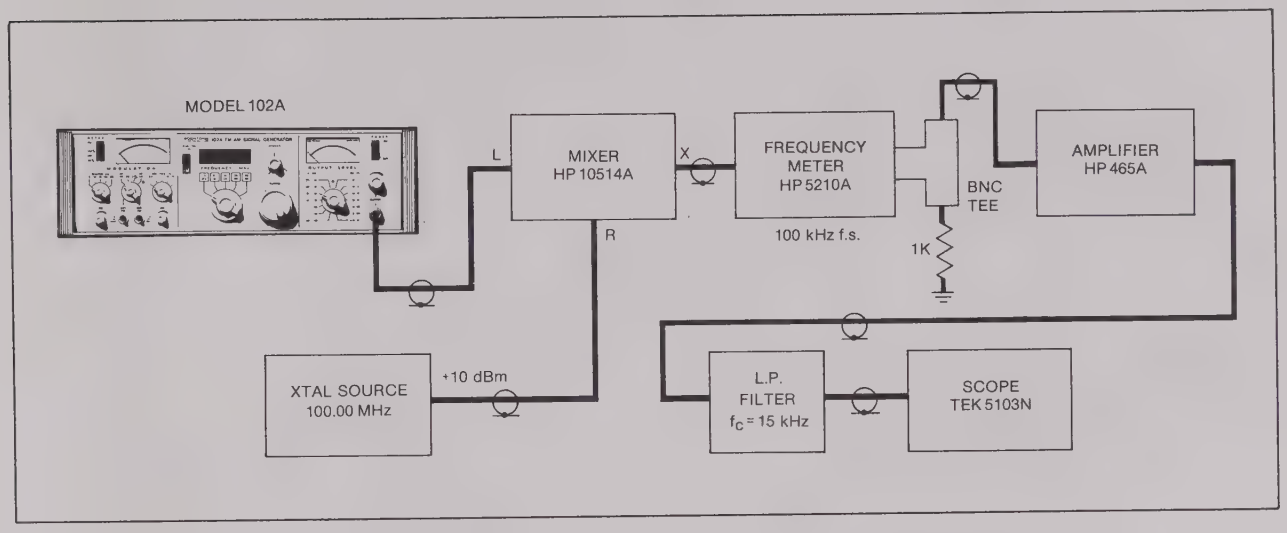


Figure 2-23 Incidental FM with AM Check, Test Setup

division. The oscilloscope is now calibrated for percentage of AM, with a scale factor of 0.1% per division.

d. Set the MODULATION function switch on the Model 102A to INT FM. Set the METER switch to FM and position the pointer of the MODULATION meter to exactly 100, using the FM control. Using the scale factor of 0.1% per division, measure the incidental AM displayed on the oscilloscope. *Incidental AM should not exceed 0.25%.*

2-48. Incidental FM With AM. To measure incidental FM, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-23.

b. Set the controls of the Model 102A as follows:

Control	Position
MODULATION function switch	INT FM
DEVIATION kHz switch	3
MOD FREQ kHz switch	1
FREQUENCY MHz switch	Band 3 (65—130)
TUNING control	100.08 MHz on output frequency indicator
METER switch	FM
FM control	10 on lower scale of MODULATION meter
OUTPUT LEVEL attenuator	0 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter

c. With the oscilloscope vertical attenuator set at 0.1 volt per division, adjust the vertical gain control as required to produce a 5 division, peak-to-peak, display of the demodulated 1 kHz signal on the oscilloscope. Set the oscilloscope vertical attenuator to 10 millivolts per division. The oscilloscope is now calibrated to measure FM deviation, with a scale factor of 20 Hz peak deviation per division.

d. Set the MODULATION function switch on the Model 102A to INT AM, and the METER switch to 30% AM. Position the pointer of the MODULATION meter to exactly 30 on the lower scale, using the AM control. Using the scale factor of 20 Hz peak deviation per division, measure the incidental FM on the oscilloscope. *Incidental FM should not exceed 100 Hz.*

2-49. Residual FM Check. To measure residual FM, proceed as follows:

a. Calibrate an oscilloscope to measure FM deviation in accordance with steps a through c of paragraph 2-48.

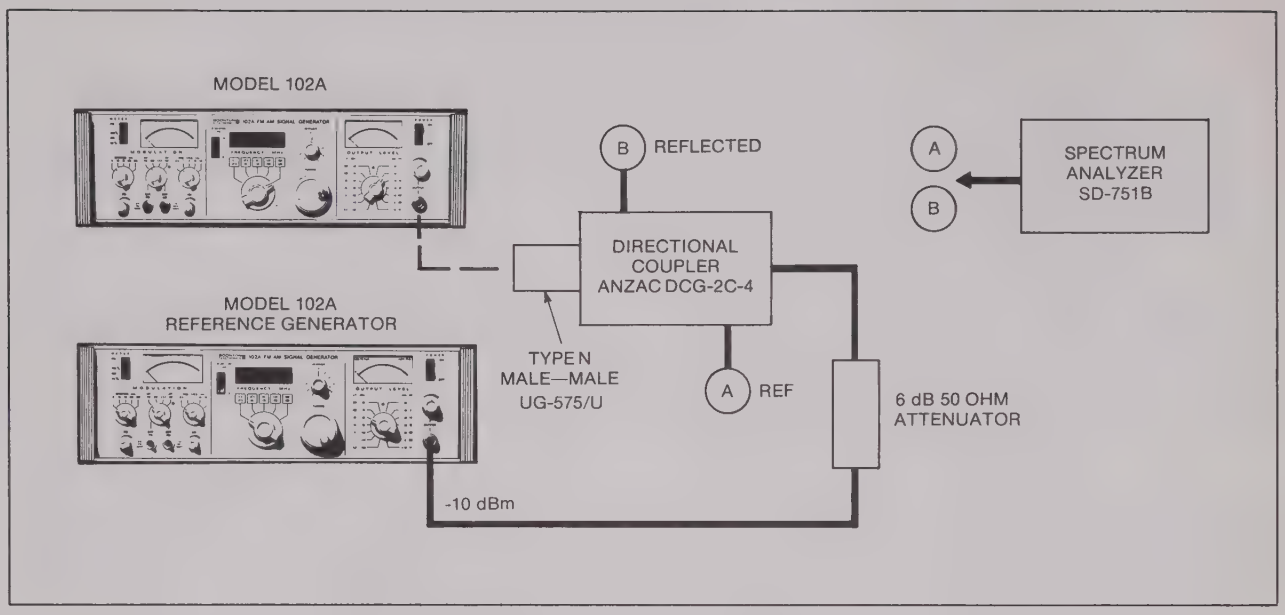


Figure 2-24 Output Impedance Check, Test Setup

b. Set the oscilloscope vertical attenuator to 5 millivolts per division. The oscilloscope is now calibrated to measure FM deviation, with a scale factor of 10 Hz peak deviation per division.

c. Set the MODULATION function switch on the Model 102A to CW. Using the scale factor of 10 Hz peak deviation per division, measure the residual FM on the oscilloscope. *Residual FM should not exceed 25 Hz.*

2-50. Output Impedance Check. To perform an output impedance check, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-24.

b. Set the controls of the *test* Model 102A and the *reference* Model 102A as follows: TABLE (2-6)

c. Connect the spectrum analyzer to point A in Figure 2-24. Adjust the spectrum analyzer controls as required to align the peak of the reference signal generator signal with the -30 dB graticule in the log display mode.

d. Connect the spectrum analyzer to point B in Figure 2-24 and observe the amplitude of the reference generator signal on the spectrum analyzer display. *The return loss, which is the difference between the amplitude observed in this step and the -30 dB amplitude of step c, should be at least 14 dB.*

TABLE 2-6. CONTROL SETTINGS FOR OUTPUT IMPEDANCE CHECK

Control	Test Model 102A	Reference Model 102A
MODULATION function switch	CW	CW
FREQUENCY MHz switch	Band 1 (4.3—37.5)	Band 1 (4.3—37.5)
TUNING control	10.0 MHz on output frequency indicator	10.3 MHz on output frequency indicator
OUTPUT LEVEL attenuator	0 dBm	-10 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter	0 dB on OUTPUT LEVEL meter

e. Tune the *test* Model 102A and the *reference* Model 102A to each of the frequencies listed below in sequence, and repeat steps c and d at each frequency. *The return loss should be as specified in step d.*

Test Model 102A	Reference Model 102A
100.0 MHz	100.3 MHz
200.0 MHz	200.3 MHz
300.0 MHz	300.3 MHz
400.0 MHz	400.3 MHz
520.0 MHz	520.3 MHz

2-51. RF Leakage Check. To check RF leakage, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-25.

b. Calibrate the RF amplifier-spectrum analyzer combination as follows:

1. Set the controls of the Model 102A as follows:

Control	Position
FREQUENCY MHz switch	Band 5 (360—520)
TUNING control	450.0 on output frequency indicator
OUTPUT LEVEL attenuator	-100 dBm
OUTPUT control	-7 dB on OUTPUT LEVEL meter
MODULATION function switch	CW

2. Adjust the spectrum analyzer scan width to 10 kHz per division, and the i-f bandwidth to 1 kHz. Phase lock the spectrum analyzer to the 450 MHz signal, and adjust the i-f attenuator as required to align the peak of the 450 MHz signal with the -40 dB graticule on the spectrum analyzer display. Set the OUTPUT LEVEL attenuator on the Model 102A to -120 dBm, and position the pointer of the OUTPUT LEVEL meter to -10 dB, using the OUTPUT control. A certain that the signal displayed on the spectrum analy.er is lower in amplitude.

c. Without disturbing any control settings, disconnect the r-f amplifier from the OUTPUT connector of the Model 102A, and connect the 50-ohm termination to the OUTPUT connector. Connect the r-f pickup loop to the input connector of the r-f amplifier.

d. Probe the surface of the Model 102A with the r-f pickup loop and observe the amplitude of the signal of the spectrum analyzer display. *The amplitude should not exceed -40 dB (1 microvolt), as measured on the spectrum analyzer display, at any position of the r-f pickup loop within 1 inch of the cabinet.*

2-52. Frequency Stability Check. To check frequency stability, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-26.

b. Set the FREQUENCY MHz switch of the Model 102A to band 3 (65—130) and the MODULATION function switch to CW. Using the TUNING control, tune the Model 102A to 100.07 MHz, as indicated on the output frequency indicator. Correct tuning will be indicated by a frequency indication of approximately 70 kHz on the frequency meter. Allow all equipment to warm up for 1 hour before proceeding further.

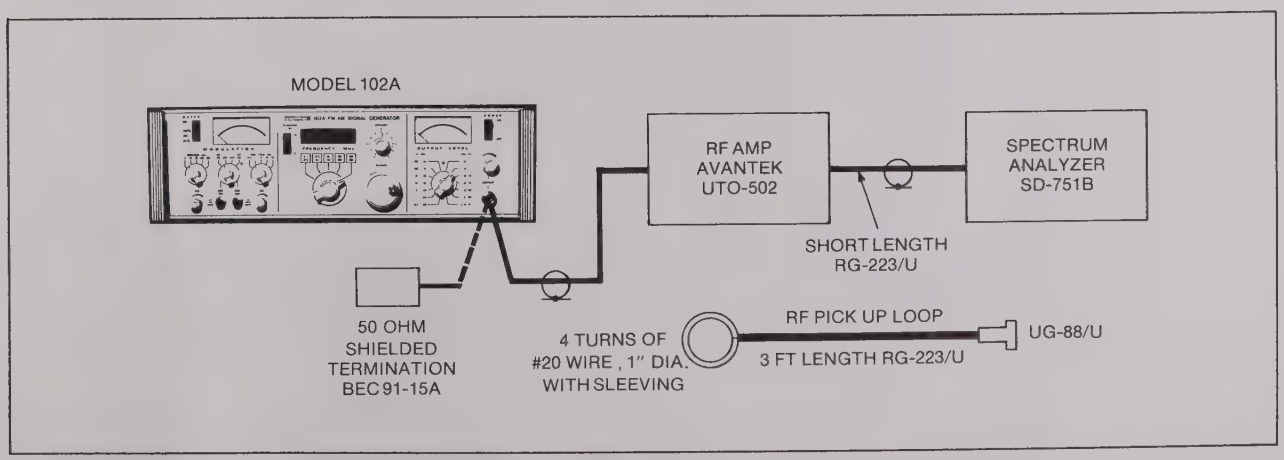


Figure 2-25 RF Leakage Check, Test Setup

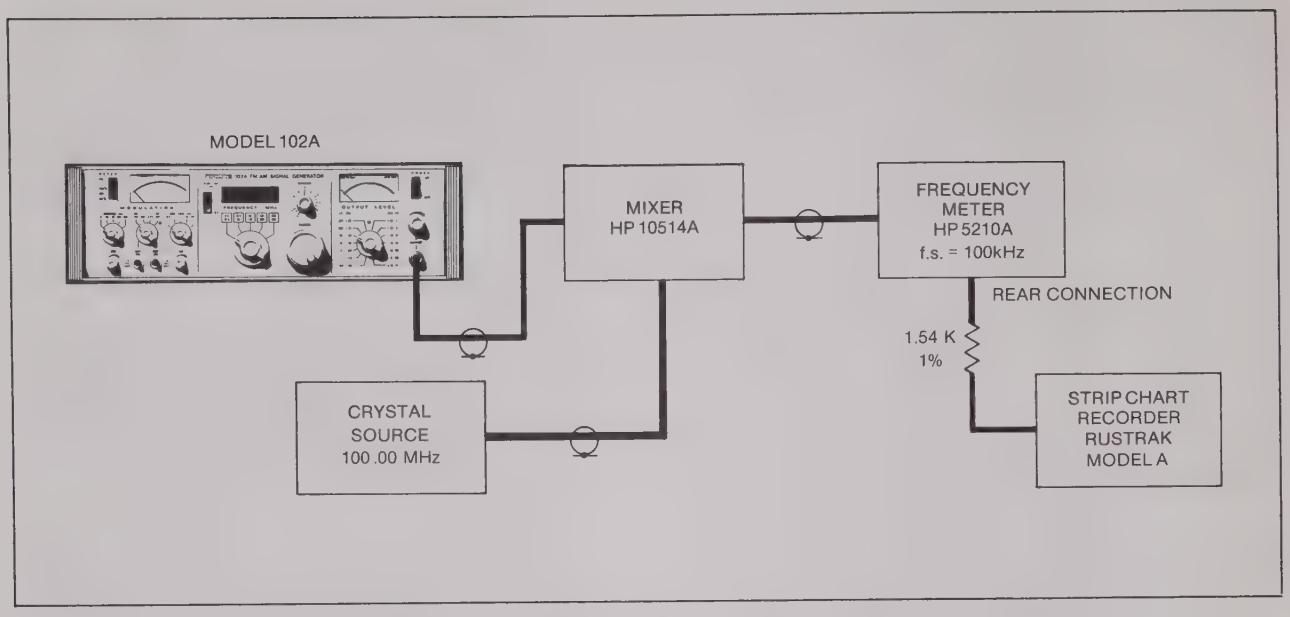


Figure 2-26 Frequency Stability Check, Test Setup

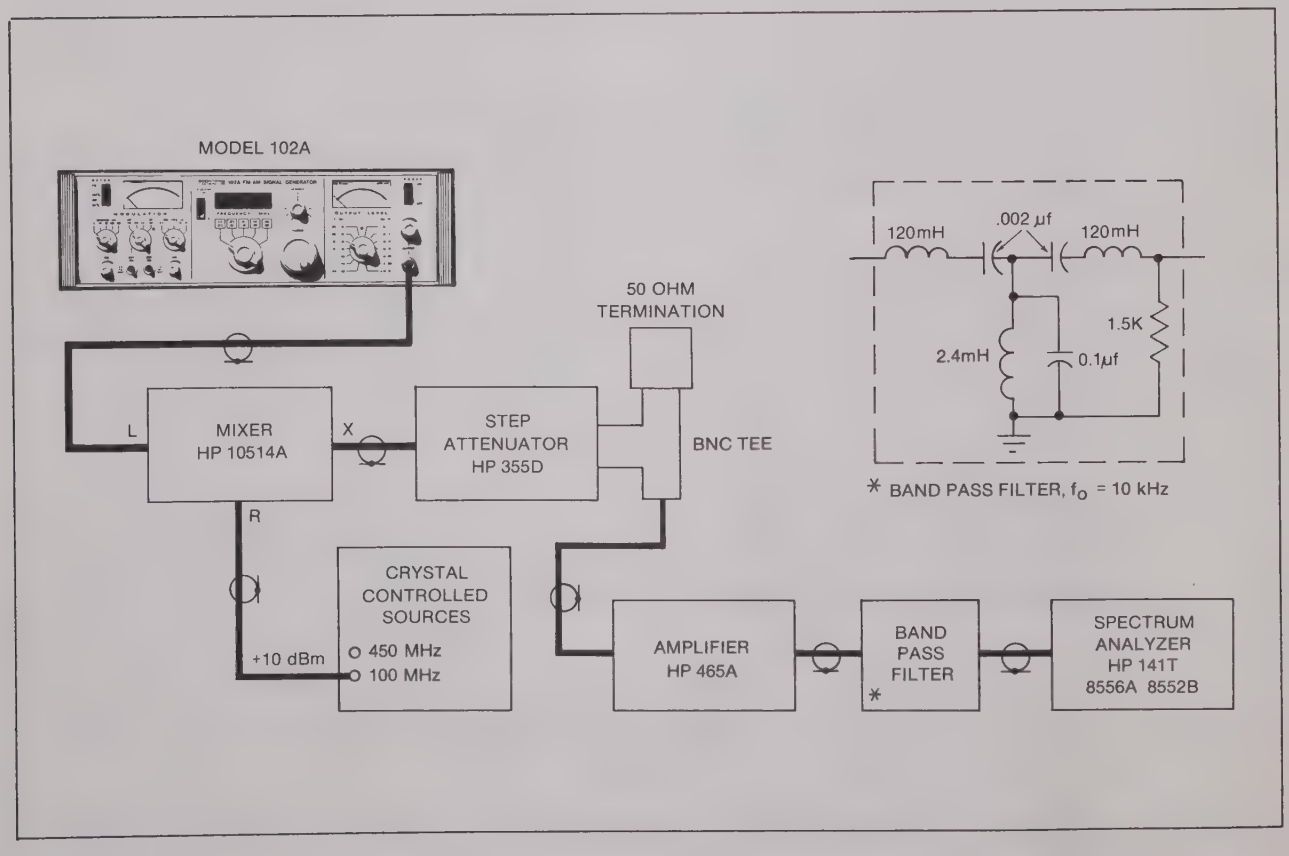


Figure 2-27 Single Sideband Phase Noise Check, Test Setup

c. Readjust the TUNING control on the Model 102A as required to obtain a 70 kHz frequency indication on the frequency meter. Set the meter switch of the frequency meter to the expand 10X position, and adjust the offset control as required to obtain an indication of 5 on the meter. The strip chart recorder is now calibrated for a full-scale sensitivity of 10 kHz, or 1 kHz per division.

d. Operate the equipment over the desired time span, making certain that the Model 102A is not subjected to excessive vibration during this period.

e. At the end of the measurement period, examine the strip chart recording. *The maximum frequency excursion in any 10 minute period should not exceed 2.0 kHz.*

NOTE

If this band meets specification, all remaining bands will be within specification limits.

2-53. Single Sideband Phase Noise Check. To check single sideband phase noise, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 2-27.

b. Set the MODULATION function switch on the Model 102A to CW, the FREQUENCY MHz switch to band 3 (65—130), and the TUNING control to the setting required to produce a 100.010 MHz indication on the output frequency indicator. Set the OUTPUT LEVEL attenuator to 0 dBm, and position the pointer of the OUTPUT LEVEL to -7 dB, using the OUTPUT control.

c. Set the step attenuator to 70 dB.

d. Set the spectrum analyzer bandwidth to 1 kHz, the scan width to 5 kHz per division, the center frequency to 10 kHz, the video filter to 10 Hz, the scan time to 1 second per division, and the input level control to the -40 dBm position.

e. The 10 kHz i-f signal should appear on the spectrum analyzer display. Using the display reference level controls, align the peak of the 10 kHz signal display with the top graticule.

f. Using the TUNING control on the Model 102A, set the output frequency to 100.030 MHz, and set the step attenuator to 0 dB. The spectrum analyzer is now calibrated for measurement of phase noise, with the top graticule representing a value of 100 dB per Hz. The i-f signal should appear at the 30 kHz position on the spectrum analyzer display. Measure the noise level at the 10 kHz position (20 kHz off the i-f signal) on the display. *The noise level should be at least 20 dB below the top graticule.*

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. FM-AM Signal Generator, Model 102A, is a compact, versatile, solid-state instrument that covers the frequency range of 4.3 to 520 MHz in five bands. The primary signal source is a very stable, spectrally pure, solid-state VFO, optimized for operation over one of the five frequency bands. Output frequencies for the other four bands are derived from the VFO output frequency through frequency division, frequency multiplication, and heterodyne techniques.

3-3. A six-digit LED display provides a direct, continuous display of output frequency. Selectable resolution capabilities of 0.1, 1, and 10 kHz are included, thereby providing direct frequency readout of up to six digits. This feature provides excellent resetability and accuracy.

3-4. A 130 dB step attenuator and an adjustable output level control provide a total output level range of −130 to +13 dBm. The selected output level is automatically maintained throughout the frequency range, independently of frequency tuning, through use of a PIN diode modulator and feedback loop. The diode modulator also provides AM modulation capability. FM modulation capability is provided through use of a varactor in the VFO resonant circuit. AM and FM can be used either separately or simultaneously, using internal and external modulating signals.

3-5. SIMPLIFIED BLOCK DIAGRAM.

(See Figure 3-1.)

3-6. General. For purposes of this discussion, the circuits of the Model 102A can be grouped by function as follows: frequency generating circuits, signal processing circuits, output circuits, modulation circuits, frequency counter circuits, and power supply circuits. The interrelationship of these functional groups is shown in Figure 3-1, and discussed in paragraphs 3-7 through 3-22. In order to simplify the discussion, switching details are not covered at this level. For a detailed description of the functional groups, refer to paragraphs 3-23 through 3-70.

3-7. Frequency Generating Circuits. The basic frequency of the Model 102A is developed by a solid-state VFO, which is tunable inductively over a range of 65 to 131.4 MHz. A varactor in the VFO resonant circuit permits electronic tuning of the VFO over a frequency range of approximately 25 kHz for vernier adjustment of output frequency. The varactor is also used to modulate the VFO for FM applications. Isolation between the VFO and the signal processing circuits is provided by a single-stage buffer amplifier. This isolation reduces incidental modulation effects which might otherwise be produced by a change in the circuit impedance of following stages because of leveling or AM operations.

3-8. Since the VFO operates over only one of the output bands, circuit design has been optimized for operation over this range, and the VFO consequently exhibits excellent frequency stability characteristics and relative freedom from residual FM. Frequency variation due to line voltage changes and supply ripple is minimized through use of a highly regulated and filtered supply voltage. The entire VFO is housed in a shielded compartment to minimize RF leakage.

3-9. Signal Processing Circuits. The signal processing circuits encompass all circuit elements required to derive the final output frequencies from the VFO output frequency. Electronic band switching is accomplished by means of PIN diodes, thus eliminating one of the major sources of instability in other signal generators and allowing use of each band without the need for extended warmup periods. Wide-band circuits are employed; therefore, tracked tuning is not required, minimizing maintenance problems and improving long-term stability.

3-10. The output frequencies for the five bands of the Model 102A are derived from the VFO output frequency as follows:

a. The frequency range of 4.3 to 37.5 MHz (band 1) is derived through heterodyne action. The VFO output frequency is divided in a binary divider circuit, and the resulting signal is heterodyned with the output of a highly-stable, crystal-controlled 70 MHz oscillator.

b. The frequency range of 32.5 to 65 MHz (band 2) is derived from the VFO output through frequency division.

c. The frequency range of 65 to 130 MHz (band 3) is derived directly from the VFO output.

d. The frequency range of 130 to 260 MHz (band 4) is derived from the VFO output through frequency multiplication.

e. The frequency range of 260 to 520 MHz (band 5) is derived from the VFO output through additional frequency multiplication.

3-11. Harmonics and other spurious signals generated as a result of frequency division, frequency multiplication, or heterodyning are suppressed by means of low-pass, high-pass, or band-pass filters. PIN diodes are used to switch the filters into the circuits electronically at the appropriate points. The output signals from the signal processing circuits exhibit excellent spectral purity because of the filtering employed.

3-12. Output Circuits. The output circuits control the amplitude of the output signal of the Model 102A. Included in the output circuits are a PIN diode modulator, an RF amplifier, a diode detector, and output level attenuating and metering circuits. All output rf circuits are wide band, covering the full 4.3 to 520 MHz range.

3-13. Signal processing circuit output signals are switched to the output circuits by means of PIN diodes. These signals are routed through a PIN diode modulator and an RF amplifier to the output level attenuator and to a diode detector. The diode detector samples the output signal amplitude and feeds back a control voltage to the diode modulator for automatic leveling of the output signal amplitude. (The diode modulator is also used for AM.) The leveling loop virtually eliminates variations in output amplitude due to changes in VFO or signal processing circuit output levels. The diode detector also supplies a DC voltage to the output level metering circuits to provide an indication of output level. Output level is adjustable in 10 dB steps by means of a precision step attenuator, and between these steps by means of the variable OUTPUT control.

3-14. Modulation Circuits. The modulation circuits process the audio voltages used for AM and FM applications. AM and FM can be used separately or simultaneously. An internal modulation oscillator is included to provide an internal modulation signal capability. Distortion, residual and incidental FM, and residual AM are exceptionally low in the Model 102A. The modulation mode is selected by means of the front panel MODULATION function switch.

3-15. When the CW mode is selected, the modulation circuits are disabled. The varactor in the VFO circuit is used only for vernier adjustments of the output frequency, and the diode modulator in the output circuits is used only for automatic leveling. The output of the Model 102A is, therefore, a stable, automatically leveled, unmodulated RF signal.

3-16. When the INT AM mode is selected, the internal modulation oscillator is energized, and the modulation circuits supply an internally generated AF modulating signal to the diode modulator. Any one of five modulation signal frequencies, 0.4 kHz, 1 kHz, 3 kHz, 10 kHz, or 19 kHz, can be selected by means of a front panel switch. The amplitude of the modulating voltage (and thus the percentage of modulation) is adjustable by means of the AM control. The MODULATION meter can be switched into the AM portion to provide a direct indication of the percentage of modulation. AM is accomplished by varying the effective shunt and series impedances of the diode modulator in the output circuits. The diode modulator provides AM modulation capabilities up to 100 percent with low distortion. Along with the internal AM, simultaneous FM using an external modulation signal source is possible. FM is accomplished by applying the external modulation signal to the varactor in the VFO. The calibrated full scale peak deviation for FM is adjustable from 3 kHz to 300 kHz, in five steps, by means of a front panel switch. The actual deviation is adjustable up to the selected full scale value by means of the FM control. The MODULATION meter can be switched into the FM portion to provide a direct indication of deviation. Because FM is accomplished at the VFO and the VFO output frequency is subject to multiplication or division in the signal processing circuits, the amplitude of the modulation signal voltage is automatically adjusted for the different output bands by means of attenuation networks switched into the FM portion by the front panel band switch. This feature ensures that deviation will remain constant, regardless of the frequency band selected.

3-17. When the INT FM mode is selected, operation of the modulation circuits is reversed in terms of the modulation signal sources. The internal modulation oscillator provides the modulation signal for the FM portion. Simultaneous AM, using an external modulation signal source, is possible. Except for the modulation signal sources, operation of the FM and AM portions of the modulation circuits is identical to that described in paragraph 3-16.

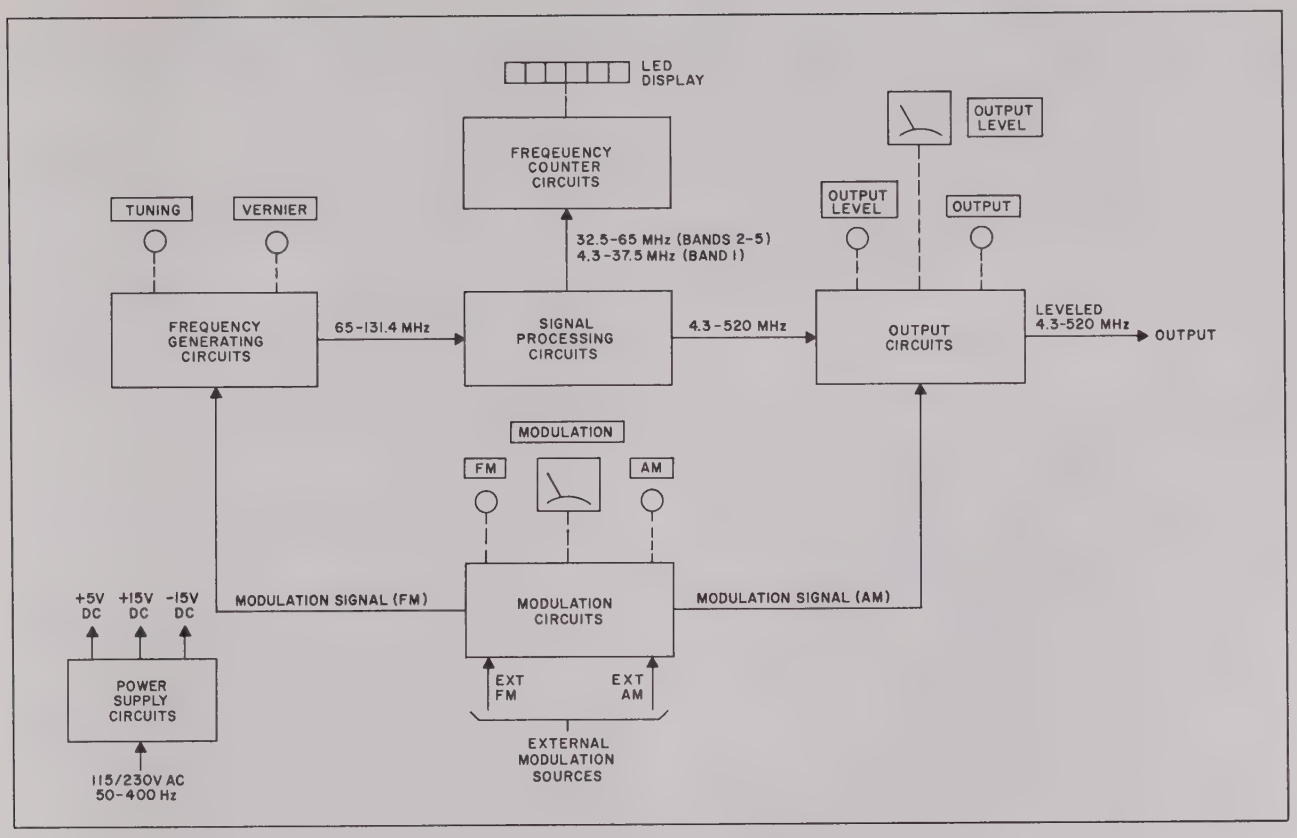


Figure 3-1 Simplified Block Diagram

3-18. When the EXT mode is selected, the internal modulation oscillator is disabled. AM and FM can be used either individually or simultaneously, but external modulation signals must be provided for both AM and FM. Except for the modulation signal sources, operation of the FM and AM portions of the modulation circuits is identical to that described in paragraph 3-16.

3-19. Frequency Counter Circuits. The frequency counter circuits provide a continuous, unambiguous display of the output frequency of the Model 102A. Resolutions of 10, 1, or 0.1 kHz are selectable by means of a front panel switch. The 10 kHz resolution provides a frequency display, in MHz, accurate to two decimal places; the 1 kHz resolution, a frequency display accurate to three decimal places; and the 0.1 kHz resolution, a frequency display accurate to four decimal places.

NOTE

Because only six digits can be accomodated by the LED frequency display, the most significant digit will be shifted out of the display when resolution is switched to 0.1 kHz at frequencies of 100 MHz and higher.

3-20. Input signals are supplied to the frequency counter circuits from the signal processing circuits. On band 1 the input signal frequency is the same as the output frequency of the Model 102A. On bands 2 through 5, the input signal frequency is one-half the VFO output frequency. A pre-scaler divides the input frequency by 10 to minimize the possibility of signal radiation from the frequency counter circuits. The frequency counter circuits generate a gate pulse, which enables a group of decade counters to count the applied signal pulses during the gate interval. Following the gate interval, six LED diodes are strobed to display the count; then, the counter circuits are reset for the next cycle of operation.

3-21. The actual number of pulses counted in the frequency counter circuits bear only a decimal relationship to the actual output frequency of the Model 102A. Note also that the input signal frequency is not affected as the Model 102A is switched from band 2 to bands 3 through 5. In order to produce a frequency display that reflects the actual output frequency, the gate pulse interval is changed as the band switch is rotated. For example, the band 3 output frequency range is twice that of band 2; therefore, the gate pulse

interval is doubled when the Model 102A is switched from band 2 to band 3. Although the frequency of the pulses applied to the frequency counter circuits has not changed, twice as many pulses will be counted because of the doubled gate pulse interval, and the LED diode display will be twice that on band 2. The gate pulse interval is again doubled in switching from band 3 to band 4, and once again doubled in switching from band 4 to band 5. The LED diode display thus corresponds to the actual output frequency of the Model 102A.

3-22. Power Supply Circuits. The power supply circuits develop the DC voltages required for operation of the internal circuits of the Model 102A. Three separate rectifier-regulator combinations are employed, providing regulated output voltages of +5 volts, + 15 volts, and −15 volts. The +15 volt rectifier also supplies an unregulated 28 volt output that powers the front panel POWER indicator lamp. The + 5 volt, + 15 volt, and −15 volt supplies are very closely regulated and well filtered in order to minimize residual FM and to enhance the stability of the Model 102A. The power supply circuits are designed for operation from either a 115 volt, or a 230 volt ac power source. A switch on the rear panel of the Model 102A alters circuit connections as required to accomodate either power source.

NOTE

The input current at 115 volts is twice that at 230 volts; therefore, the line fuse must also be changed when switching from a 115 volt power source to a 230 volt power source, or vice versa.

3-23. DETAILED THEORY OF OPERATION, FREQUENCY GENERATING CIRCUITS.

(See Figure 3-2.)

3-24. The basic frequency source of the Model 102A is the VFO, which is a highly stable, solid-state oscillator, optimized for operation over the frequency range of 65 to 131.4 MHz. Main tuning is accomplished by means of a variable inductor, thus reducing microphonism to a very low level. Varactors in the resonant circuit of the VFO provide FM and electronic fine tuning capabilities. The effective capacitance of the varactors is controlled by a DC bias voltage, adjustable by means of the VERNIER control, and by the FM modulation signal. A variable capacitor, tracked to the TUNING control, maintains the deviation sensitivity of the varactors essentially constant over the entire tuning range of the VFO. The VFO is completely shielded to prevent r-f radiation.

3-25. The r-f signal generated by the VFO is applied to a single-stage buffer amplifier which provides isolation between the VFO and the following signal processing circuits. This isolation reduces incidental modulation effects which might be produced by changes in the input impedance of the diode modulator in the output circuits as a result of leveling and AM operations. The buffer amplifier supplies a 1 Vrms signal to the signal processing circuits for bands 3 through 5, and a separate 1 Vrms signal to the signal processing circuits for bands 1 and 2.

3-26. DETAILED THEORY OF OPERATION, SIGNAL PROCESSING CIRCUITS.

3-27. Bands 1 and 2. (See Figure 3-3.) The output frequency range of 32.5 to 65 MHz (band 2) is derived from the VFO output frequency range by means of frequency division. The output frequency range of 4.3 to 37.5 MHz (band 1) is obtained by heterodyning the divided output of the VFO with the output of a highly stable, crystal controlled, 70 MHz oscillator.

3-28. The output r-f signal of the VFO, within the frequency range of 65 to 131.4 MHz, is applied through a four-stage isolation amplifier to a binary divider. The isolation amplifier is employed because the binary divider has little input-output isolation, and the output of the binary divider appears as a subharmonic of the output frequency on the three highest bands of the Model 102A. The binary divider consists basically of an astable multivibrator, which is synchronized by the 65 to 131.4 MHz signal supplied by the isolation amplifier. The 32.5 to 65.7 MHz output of the binary divider is used on all bands of the Model 102A. On bands 1 and 2, it is used in the signal processing circuits to develop the output frequency of the Model 102A. On bands 2 through 5, it is applied to the frequency counter circuits to produce a display of the output frequency of the Model 102A.

3-29. Because the binary divider employs a multivibrator circuit, the output is rich in harmonics. If the spectral purity of the Model 102A is to be maintained, these harmonics must be suppressed. Two low-pass filters are employed for this purpose, one covering the frequency range of 0 to 47 MHz, and the second, the frequency range of 0 to 68 MHz. Selection of the appropriate filter is accomplished electronically by means of PIN diodes and a cam-operated switch coupled to the TUNING control. When the TUNING control is

set to a frequency between 32.5 and 45 MHz, +15 volts DC is applied by the cam-operated switch to the diodes, forward-biasing diodes CR405 and CR407, and reverse-biasing diodes CR404 and CR406. The binary divider output signal is then routed through conducting diodes CR405 and CR407 and the 0 to 47 MHz filter to a section of the FREQUENCY MHz switch. When the TUNING control is set to a frequency between 45 and 65 MHz, −15 volts DC is applied by the cam-operated switch to the diodes, diodes CR404 and CR406 are forward-biased, and the 0 to 68 MHz filter is connected into the signal path. Note that two filters are required because of the harmonic relationship between the low-frequency and high-frequency ends of the tuning range. If one filter covering a frequency range of 0 to 68 MHz were employed, the second harmonic of a 32.5 MHz output signal, for example, would fall within the pass band of the filter and would not be suppressed. Depending upon the setting of the FREQUENCY MHz switch, the output r-f signal from the selected low-pass filter is applied either to the output circuits (band 2) or to mixer Z401 (band 1).

3-30. When the FREQUENCY MHz switch is set to 4.3—37.5 (band1), the filtered 32.5 to 65.7 MHz signal is applied to one input of mixer Z401, and +15 volts DC is supplied to energize crystal oscillator Q414 and dual amplifier Q410 through Q413. The second input to the mixer consists of the 70 MHz output signal from the crystal oscillator. The difference signal (4.3 to 37.5 MHz) developed by the mixer is applied to separate channels of dual channel amplifier Q410 through Q413. One channel supplies a 4.3 to 37.5 MHz signal to the output circuits, and the second channel supplies a 4.3 to 37.5 MHz signal to the frequency counter circuits. The separate input to the frequency counter circuits on band 1 is required because the integer relationship that exists between the Model 102A output frequency and the binary divider output frequency on the four higher bands is voided by the mixing process.

NOTE

Because the crystal oscillator frequency is above the binary divider output frequency, the difference frequency will decrease as the VFO frequency is increased; therefore, on band 1, clockwise rotation of the TUNING control results in a decrease in the output frequency of the Model 102A. On all other bands, clockwise rotation of the TUNING control results in an increase in the output frequency.

3-31. Bands 3 through 5. (See Figure 3-4.) The output frequency range for band 3 falls within the tuning range of the VFO. The signal processing circuits for band 3, therefore, consist only of two low-pass filters, which are electronically switched into the output signal path by means of diodes. One filter has a

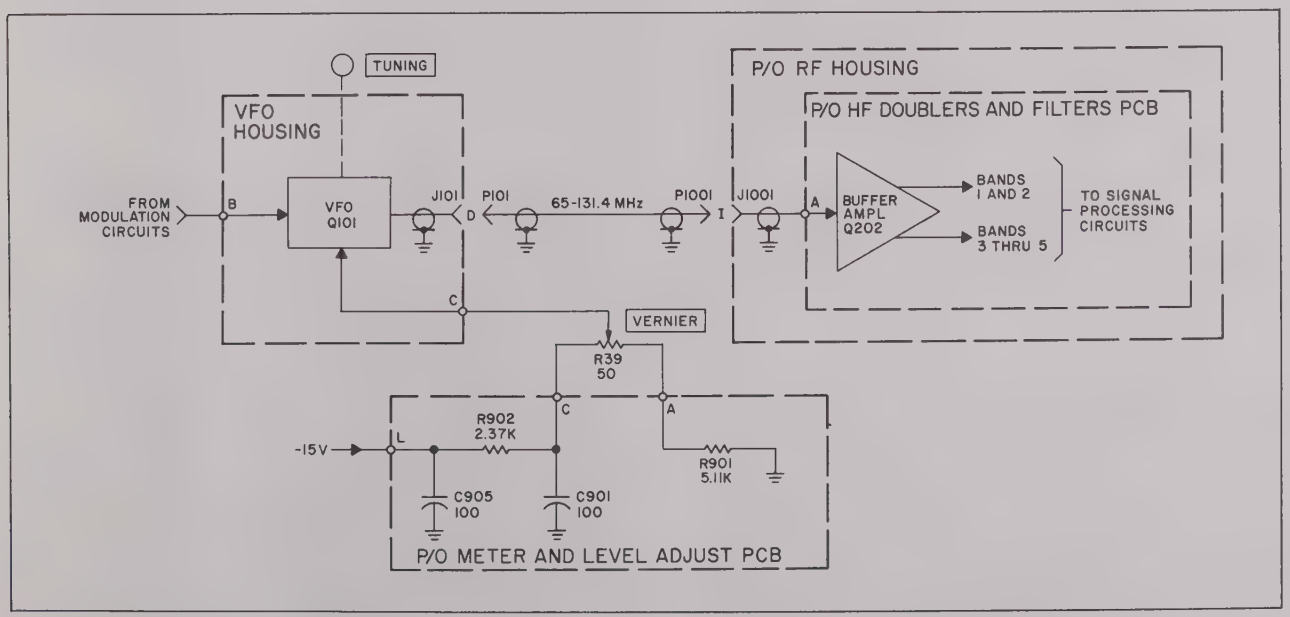


Figure 3-2 Frequency Generating Circuits, Detailed Block Diagram

pass band of 0 to 93 MHz, and the second, a pass band of 0 to 135 MHz. When the FREQUENCY MHz switch is set to band 3 and the TUNING control is set to an output frequency from 65 to 90 MHz, a cam-operated switch coupled to the TUNING control applies +15 volts DC to diodes CR202, CR203, CR205, and CR206, and the 0 to 93 MHz filter is effectively connected into the signal path by forward-biased diodes CR202 and CR205 to suppress harmonics and other spurious signals. When the TUNING control is set to an output frequency from 90 to 130 MHz, −15 volts DC is supplied to the diodes by the cam-operated switch, and the 0 to 135 MHz filter is effectively connected into the signal path by forward-biased diodes CR203 and CR206. The filtered 65 to 130 MHz output signal is switched electronically to either the output circuits (band 3) or to the band 4 signal processing circuits (band 4 and 5) by means of diodes CR204 and CR207, respectively. Control voltage for the diodes is supplied through a section of the FREQUENCY MHz switch.

3-32. The band 4 frequency range of 130 to 260 MHz is derived by means of a wide-band, full-wave, frequency doubler circuit, driven at the VFO frequency. The filtered 65 to 130 MHz output of the band 3 signal processing circuits is applied to first doubler CR208A-CR208B when the FREQUENCY MHz switch is set to band 4. This input frequency and undesired harmonics are filtered from the 130 to 260 MHz output of the first doubler by electronically switched band-pass filters. A 130 to 158 MHz, 158 to 205 MHz, or 205 to 260 MHz band-pass filter is automatically switched into the signal path at appropriate points in the output frequency range by means of diodes, powered by DC voltages applied from cam-operated switches coupled to the TUNING control. Additional filtering of the 65 to 130 MHz first doubler input frequency is provided by a high-pass filter. The filtered, 130 to 260 MHz r-f output signal is applied either to the output circuits (band 4) or to the band 5 signal processing circuits (band 5). A section of the FREQUENCY MHz switch supplies appropriate DC voltages to diodes CR215 and CR216 to accomplish the output signal switching electronically.

3-33. The 260 to 520 MHz output frequency range for band 5 is derived in a manner similar to that for band 4. When the FREQUENCY MHz switch is set to band 5, −15 volt DC operating power is supplied to band 5 driver Q206—Q207, and the 130 to 260 MHz output of the band 4 signal processing circuits is switched to the band 5 driver through diode CR216. The band 5 driver is a two-stage amplifier that provides the approximately 5 milliwatt input power level required for operation of second doubler CR208C-CR208D. The applied 130 to 260 MHz input frequency is doubled by the second doubler, and the resulting 260 to 520 MHz r-f output signal is applied to band-pass filters which provide suppression of harmonic and subharmonically related components. Three band-pass filters of interdigital stripline design are used for band 5. The filters are switched into the signal path at appropriate points in the frequency range by diodes powered by DC voltages supplied by cam-operated switches coupled to the TUNING control. The filtered 260 to 520 MHz output from the filters is applied to the output circuits.

3-34. DETAILED THEORY OF OPERATION, OUTPUT CIRCUITS.

(See Figure 3-5.)

3-35. The output circuits of the Model 102A provide wide-band r-f amplification, automatic leveling, amplitude modulation, and output level adjusting and metering capabilities. Input r-f signals are supplied to the output circuits from the signal processing circuits.

3-36. Input signal switching is accomplished electronically by means of diodes CR601 through CR605. The diodes are powered individually by DC voltages supplied through one section of the FREQUENCY MHz switch. The selected r-f input signal is coupled through the corresponding forward-biased diode to the AM diode modulator. The AM diode modulator performs two functions: automatic leveling and amplitude modulation. The AM diode modulator consists of shunt and series connected PIN diodes, whose impedance is determined by a control voltage supplied by difference amplifier A602. By varying the shunt and series impedances of the diodes, the amplitude of the r-f output signal of the Model 102A can be varied.

3-37. For automatic leveling operations, a level determined by the setting of the OUTPUT control is applied as one input to differential amplifier A602. The second input is a DC voltage derived from detecting the r-f output signal of the Model 102A, and having a magnitude proportional to the r-f output signal amplitude. As long as the dc level corresponds to the level selected by means of the OUTPUT control, the output r-f level remains constant. If the output level of the Model 102A should tend to deviate from the preset level, a feedback signal is developed by the differential amplifier, and the feedback signal changes the impedances of the diodes in the AM diode modulator in the proper direction to compensate for the change in the output level. The feedback loop maintains the output level of the Model 102A within ±0.5 dBm of the selected value regardless of frequency changes within a particular band.

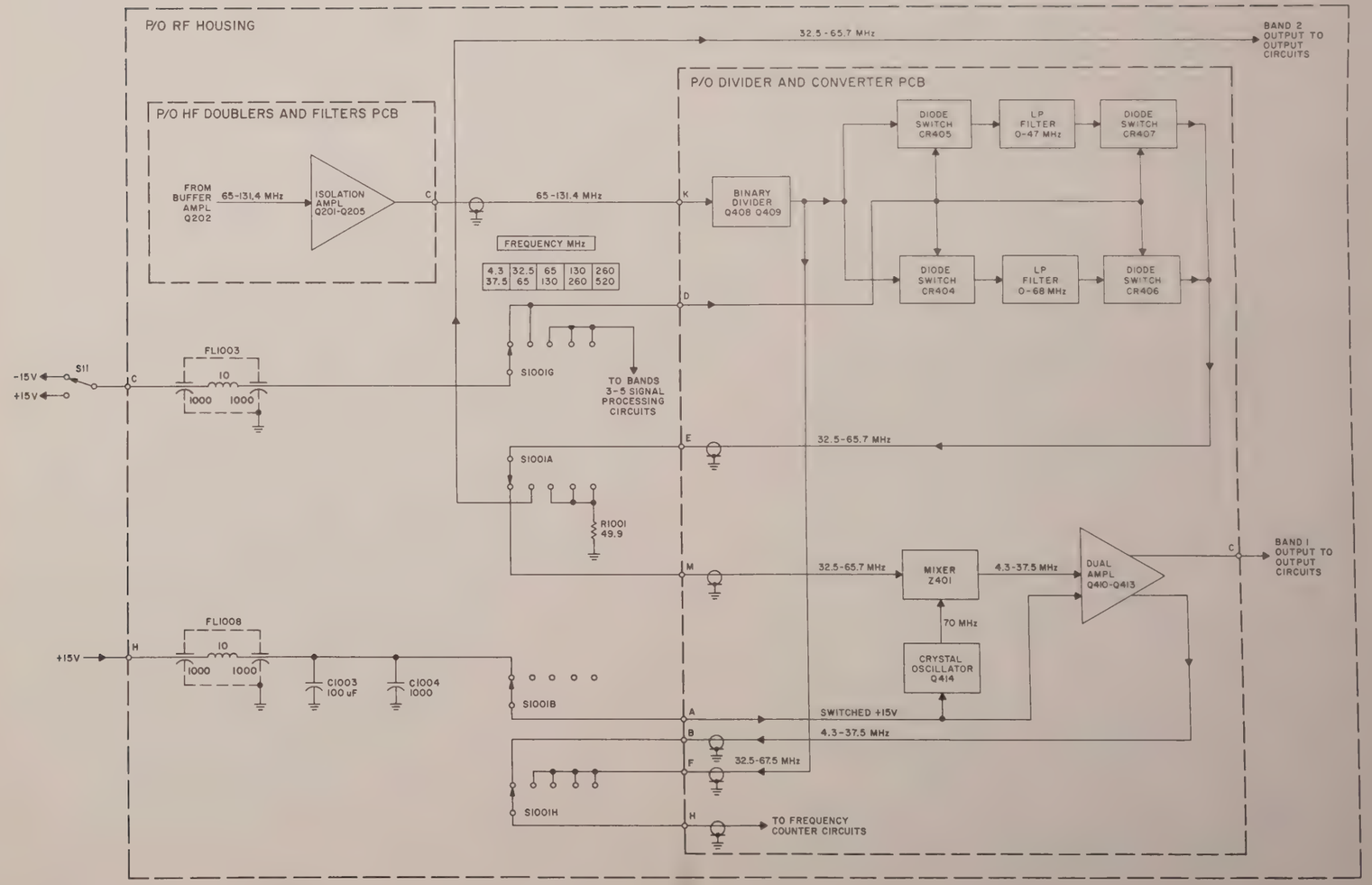


Figure 3-3 Signal Processing Circuits, Bands 1 and 2, Detailed Block Diagram

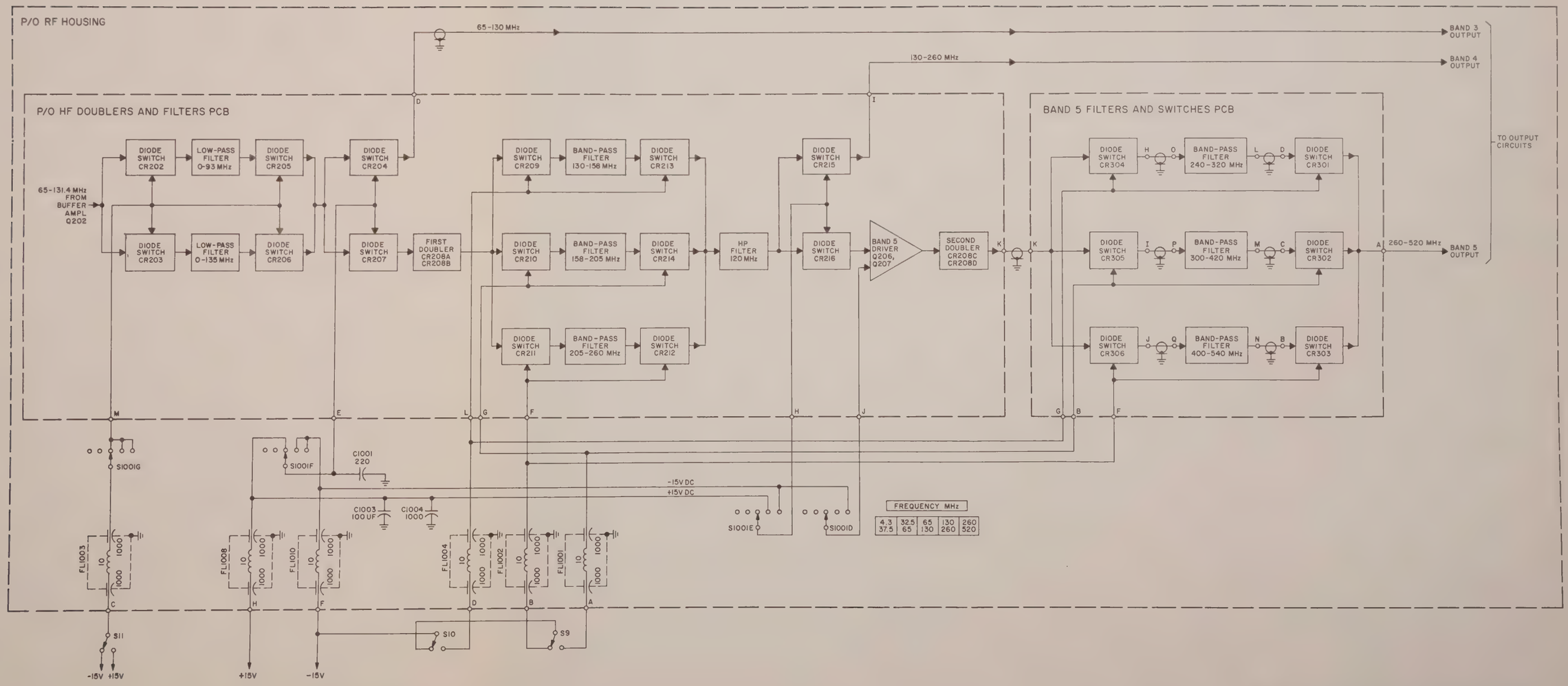


Figure 3-4 Signal Processing Circuits, Bands 3 through 5, Detailed Block Diagram

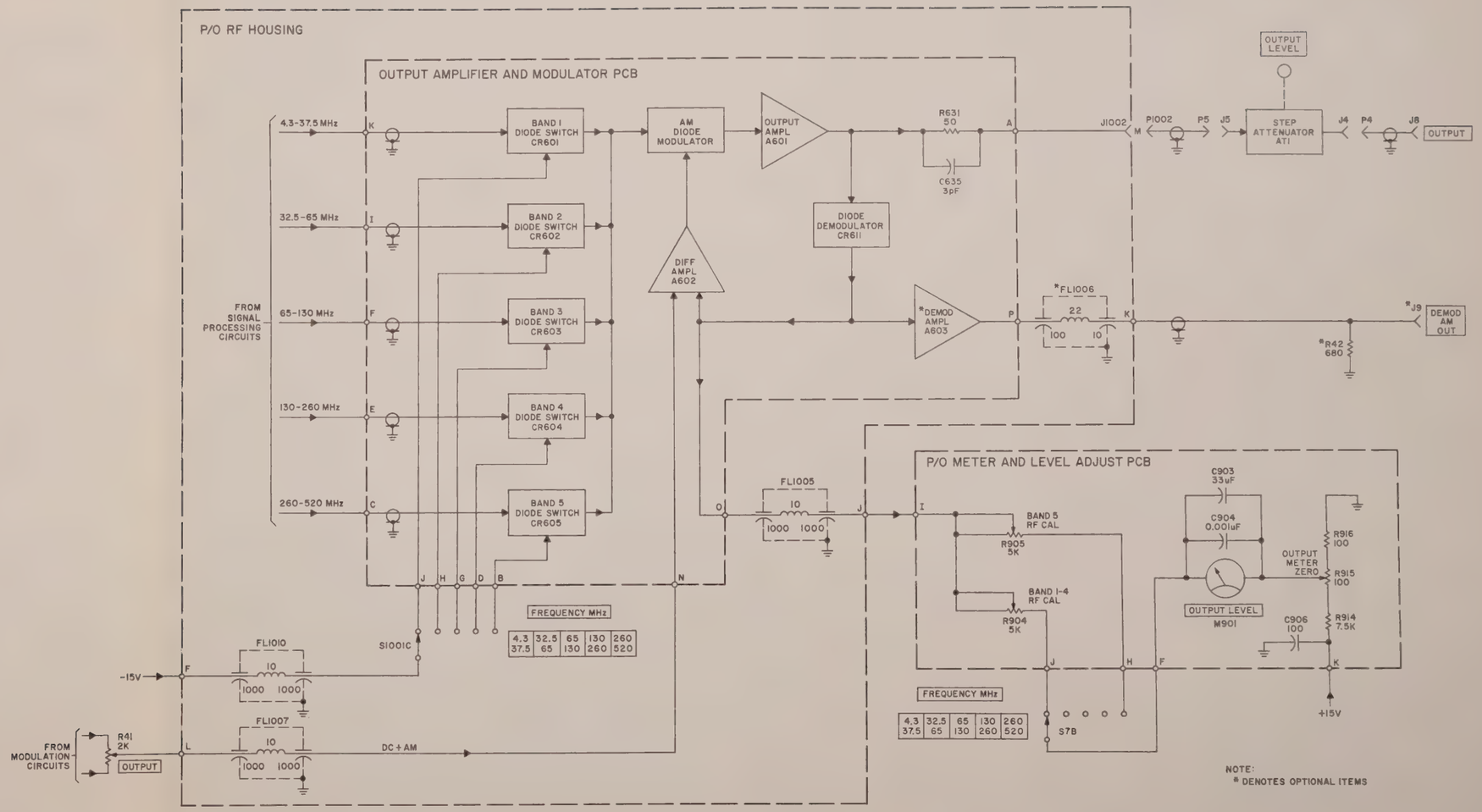


Figure 3-5 Output Circuits, Detailed Block Diagram

3-38. For AM operation, the modulation signal voltage is superimposed upon the DC level applied from the OUTPUT CONTROL. The output of differential amplifier A602 is, therefore, a signal that corresponds to the modulation signal. The impedances of the diodes in the AM diode modulator vary in accordance with the modulation signal, and the r-f output of the AM diode modulator is an AM signal. When this signal is detected by diode demodulator CR611 a modulation signal component will be present in the diode demodulator output along with the DC component, and negative feedback at the modulation signal frequency occurs. This negative feedback improves the linearity of AM, especially at low modulation signal frequencies. At the higher modulation signal frequencies, the amplitude of the feedback will decrease because of a low-pass filter in the path from the diode demodulator circuit. A matched low-pass filter in the modulation circuits compensates for this variation in feedback to prevent the overall sensitivity from increasing as the feedback is reduced.

3-39. The output signal of the AM diode modulator is amplified by wide-band r-f amplifier A601, then applied to the OUTPUT LEVEL attenuator through a 50 ohm resistor which establishes the source impedance. The r-f amplifier also supplies the input signal for diode demodulator CR611. In addition to its leveling function previously mentioned, the diode demodulator supplies DC to the OUTPUT LEVEL meter to provide a direct indication of the output level of the Model 102A. The scale of the OUTPUT LEVEL meter is calibrated to indicate both dBm and voltage levels for a 50 ohm load. Potentiometer R915 provides a means for electrical zeroing of the OUTPUT LEVEL meter, potentiometer R905 is used to calibrate the meter of band 5, and potentiometer R904 is used to calibrate the meter on the four remaining bands. If the Model 102A is equipped with option 03, the detected AM modulation signal developed in the diode demodulator circuit is also applied to amplifier A603. Amplifier A603 is a voltage follower, which provides an isolated demodulated AM output signal that is available at a rear panel connector of the Model 102A.

3-40. The 4.3 to 520 MHz r-f output signal of r-f amplifier A601 is applied through the OUTPUT LEVEL attenuator to the front panel OUTPUT connector. The OUTPUT LEVEL attenuator is a precision step attenuator, providing output levels of −120 dBm to +10 dBm in 10 dBm steps. The OUTPUT control discussed in paragraph 3-37 provides a means for further adjustment of the output level. Using the OUTPUT LEVEL attenuator and the OUTPUT control, the output level of the Model 102A can be adjusted to any value within the range of −130 dBm to +13 dBm.

3-41. DETAILED THEORY OF OPERATION, MODULATION CIRCUITS.

(See Figure 3-6.)

3-42. General. The modulation circuits process the modulation signals required for amplitude modulation and frequency modulation of the Model 102A output signal. The modulation circuits also include a modulation oscillator, which provides an internal modulation signal. FM is accomplished through use of the varactors in the VFO tank circuit; AM, through use of the diode modulator in the output circuits.

3-43. Internal FM. When the MODULATION function switch is set to INT FM, the Model 102A output signal can be frequency modulated using the internal modulation oscillator as the modulation signal source. Simultaneous AM, using an external modulation signal source, is also possible. Two sections of the MODULATION function switch supply +15 volt and −15 volt DC operating power to modulation oscillator A501 and emitter follower Q501. Modulation oscillator A501 uses a Wein-bridge circuit to generate the modulation signal. The frequency of oscillation is determined by the resistance-capacitance network connected into the modulation oscillator circuit. The MOD FREQ kHz switch provides means for selecting any one of five different resistance networks, allowing selection of modulation signal frequencies of 0.4 kHz, 1 kHz, 3 kHz, 10 kHz, or 19 kHz. Emitter follower Q501 provides an isolated modulation signal output to the rear panel MOD FREQ OUT connector for synchronization of external equipment.

3-44. The internally generated modulation signal is applied through a section of the MODULATION function switch to the FM modulation circuits. The amplitude of the modulation signal (and thus the FM deviation) is adjustable by means of the constant impedance FM control. The maximum calibrated deviation is established by the setting of the DEVIATION kHz switch, which inserts appropriate constant-impedance, resistive attenuation networks into the circuit. A second series of constant-impedance resistive attenuation networks is controlled by the FREQUENCY MHz switch. Frequency multiplication or frequency division of an FM signal, as occurs in the Model 102A, results in a corresponding multiplication or division of the deviation. The resistive attenuation networks inserted into the FM modulation signal path by the FREQUENCY MHz switch adjust the amplitude of the FM modulation signal to compensate for this effect. On bands 1 and 2, no attenuation network is used. The band 3 output frequency range is twice that of band 2; therefore, the FM deviation at the VFO is reduced to

half the value on band 2 through insertion of an appropriate resistive attenuation network. On band 4, the deviation at the VFO is again reduced by a factor of two, and another reduction occurs in switching from band 4 to band 5. The deviation at the output of the Model 102A thus remains constant regardless of the band selected.

3-45. The actual deviation in FM applications is determined by the setting of the DEVIATION kHz switch and the FM control. Because deviation is proportional to the amplitude of the modulation signal, an indirect indication of deviation can be obtained by measuring the modulation signal amplitude. A portion of the modulation signal is applied through calibrating potentiometer R502 and the METER switch (FM position) to modulation detector A502-A503, and the modulation detector output is applied to the front panel MODULATION meter to provide an indication of the actual deviation. (The meter scale is calibrated to indicate deviation.)

3-46. Simultaneous AM, using an external modulation signal source, can also be used with internal FM. Operation of the AM modulation circuits using an external modulation signal source is described in paragraph 3-51.

3-47. Internal AM. When the MODULATION function switch is set to INT AM, the Model 102A output signal can be amplitude modulated using the internally generated modulation signal. Simultaneous FM, using an external modulation signal source, is also possible. Two sections of the MODULATION function switch apply DC operating power to modulation oscillator A501 and emitter follower Q501, and these circuits operate as described in paragraph 3-43.

3-48. The internally generated modulation signal is applied through a section of the MODULATION function switch to the AM control, which provides a means for varying the amplitude of the modulation signal and thus the percentage of AM. The modulation signal is then amplified by audio amplifier Q901, and the output of the audio amplifier is applied through the OUTPUT control to the modulation circuits. The voltage at the arm of the OUTPUT control consists of a DC component, which establishes the reference level of the Model 102A output signal, and an a-f component, which produces the AM. Both the a-f and DC components vary as the OUTPUT control is adjusted; therefore, the percentage of modulation remains constant regardless of the output level selected.

3-49. A portion of the modulation signal is applied from the input circuit of the audio amplifier by potentiometer R907 through the METER switch (30% AM or 100% AM position) to the metering circuits to provide an indication of the percentage of AM. Two meter ranges are provided for AM, 0 to 30%, and 0 to 100%. An appropriate scaling resistor is inserted into the meter circuit by the METER switch when the switch is set to the 100% AM position.

3-50. Simultaneous FM, using an external modulation signal source, can be used with internal AM. Operation of the FM modulation circuits using an external modulation signal source is described in paragraph 3-51.

3-51. External. When the MODULATION function switch is set to EXT, both AM and FM can be used simultaneously, but external modulation signal sources are required for both AM and FM. Internal modulation oscillator A501 and emitter follower Q501 are disabled through removal of DC operating power. Modulation signals from external signal sources are applied through the front panel EXT AM and EXT FM connectors, and are routed through separate sections of the MODULATION function switch. Except for the modulation signal sources, the FM and AM modulation circuits function as described in paragraphs 3-44 through 3-45, and 3-48 through 3-49, respectively.

3-52. CW. When the MODULATION function switch is set to CW, the Model 102A produces an unmodulated output signal. With the switch in the CW position, DC operating power is removed from modulation oscillator A501 and emitter follower Q501, and the FM and AM modulation circuit inputs are grounded. The varactors in the VFO are, therefore, affected only by the DC voltage supplied from the VERNIER control, and the diode modulator in the output circuits is affected only by the DC reference voltage supplied from the OUTPUT control.

3-53. DETAILED THEORY OF OPERATION, FREQUENCY COUNTER CIRCUITS.

(See Figure 3-7.)

3-54. The frequency counter circuits provide a continuous display of the output frequency of the Model 102A. The elimination of a tuning dial, with its recalibration problems and inherent reading uncertainty, eliminates one major source of operator error and maintenance problems. A six-digit LED display with adjustable resolution is used for the output frequency indicator. The output frequency is displayed in a clear, unambiguous manner, simplifying tuning and enhancing resettability.

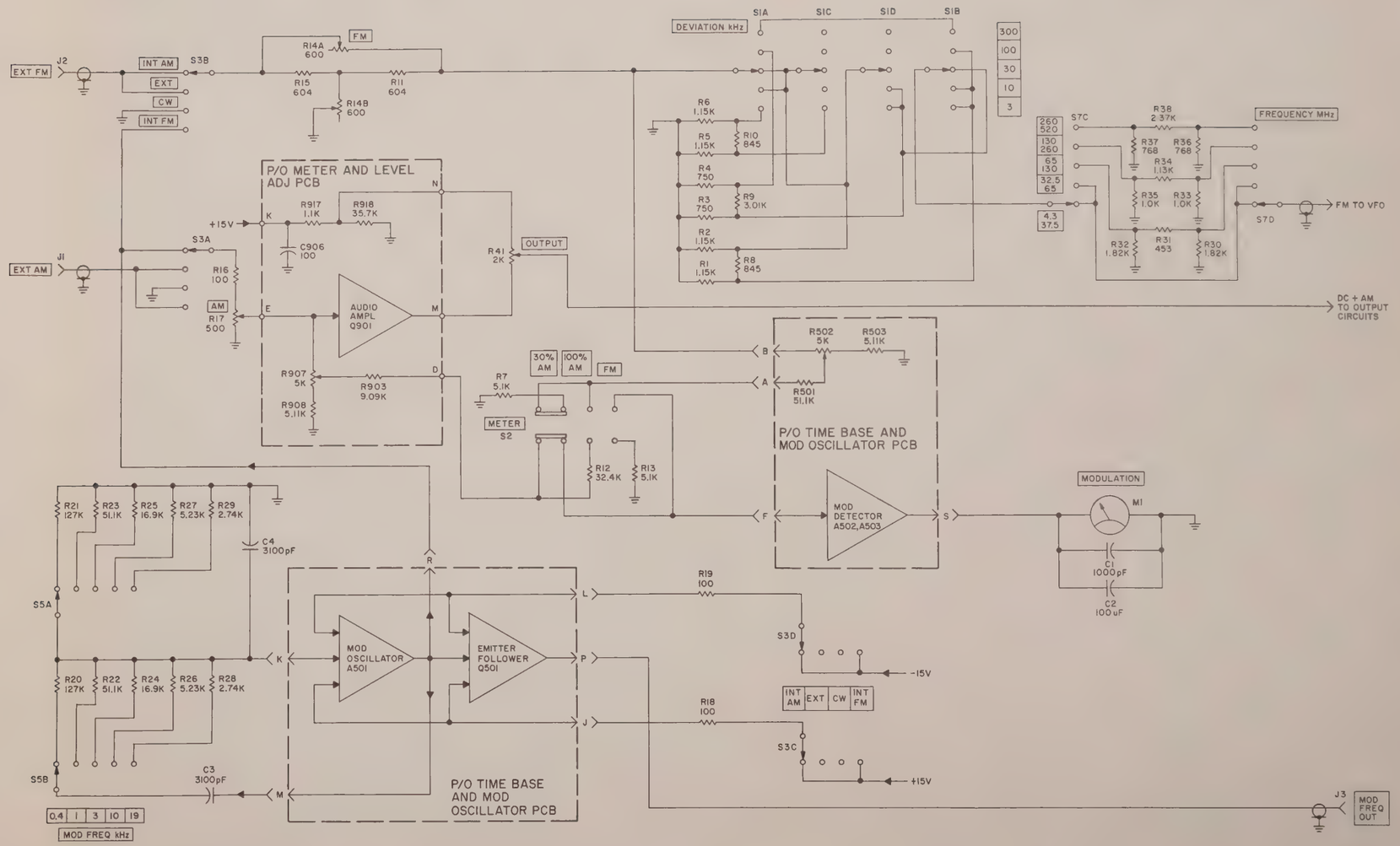


Figure 3-6 Modulation Circuits, Detailed Block Diagram

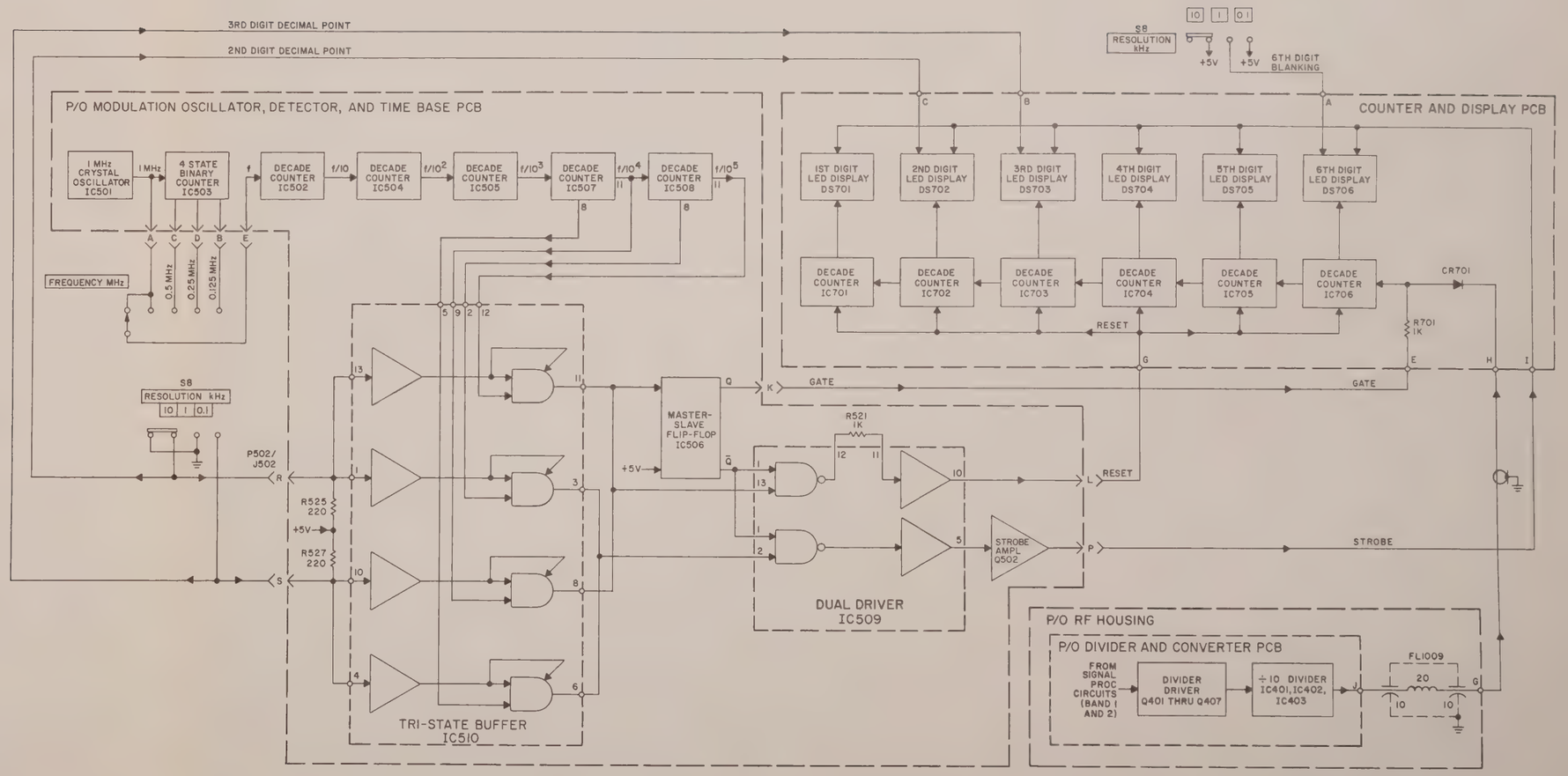


Figure 3-7 Frequency Counter Circuits, Detailed Block Diagram

3-55. The input frequency to the frequency counter circuits is one-half the VFO operating frequency (bands 2 through 5) or the actual output frequency (band 1). The input signal is applied from the signal processing circuits to a seven-stage driver amplifier. The output of the driver amplifier drives a prescaler, which divides the applied frequency by a factor of 10. The signal frequency employed in the actual frequency counter circuits and the LED display is thus at a much lower frequency than the output frequency of the Model 102A, minimizing the possibility of unwanted r-f radiation. To obtain a frequency display that corresponds to the actual output frequency, a suitable gate time is selected so that the number of pulses counted bears a decimal relationship to the output frequency on each band.

3-56. The sequence of events involved in each cycle of operation is as follows:

a. A gate pulse of suitable duration is generated.

b. The number of input signal pulses applied during the gate pulse interval is counted and stored by six decade counters.

c. After the gate pulse has been terminated, a strobe pulse is applied to the LED displays, and the count stored by each of the decade counters is displayed and stored by the corresponding LED display.

d. A reset pulse is then generated, and the decade counters are reset for the next cycle of operation.

3-57. Crystal oscillator IC501 provides a stable 1 MHz frequency which establishes the timing of the gate, strobe, and reset pulses. The crystal oscillator employs two cross-connected NAND gates, with a 1-MHz crystal as one of the coupling elements. Three other timing frequencies, 0.5 MHz, 0.25 MHz, and 0.125 MHz, are derived from the 1 MHz output frequency of the crystal oscillator through frequency division in 4-bit binary counter IC503. Selection of the proper timing frequency is accomplished by means of one section of the FREQUENCY MHz switch.

3-58. The selected timing frequency is further divided by either four or five decade counters, depending upon the setting of the RESOLUTION kHz switch. The gate time corresponds to the period (1/f) of the output of the last decade counter employed. For resolutions of 10 kHz or 1 kHz, the output of decade counter IC507 is gated through tri-state buffer IC510 to master-slave flip-flop IC506. The flip-flop is switched on and off alternately by the applied timing pulses to develop the gate pulses. Gate durations for 10 kHz and 1 kHz resolutions are 10 milliseconds for bands 1 and 2, 20 milliseconds for band 3, 40 milliseconds for band 4, and 80 milliseconds for band 5. During the gate interval, the Q output of flip-flop IC506 is at a logical 1 level, diode CR701 is forward biased, and decade counters IC701 through IC706 are toggled according to the number of incoming pulses passing through the diode.

3-59. Master-slave flip-flop IC506 is then triggered again and reverses its state. The Q output drops, and the $\overline{Q}$ output switches to a logical 1 level. At this time, diode CR701 is gated off and no additional count of frequency pulses can occur. During this period, a logical 1 level clock pulse is developed at terminal 8 of decade counter IC507 and is gated through tri-state buffer IC510 to one section of dual driver IC509. Since the $\overline{Q}$ signal input to this section is also at a logical 1 level at this time, an output pulse is developed at the output of this section of the dual driver. After amplification and inversion by Q502, this strobe pulse is applied to the LED displays, and the LED's display and store the count registered in the corresponding decade counters.

3-60. As the pulse at terminal 8 of decade counter IC507 is terminated, an output pulse at terminal 11 is generated and gated through tri-state buffer IC510 to the second section of dual driver IC509. Since both inputs to this dual driver section are at a logical 1 level, a reset pulse is generated and applied to decade counters IC701 through IC706, resetting them to zero. As soon as master-slave flip-flop IC506 changes its state, the reset pulse is terminated, the Q output of the flip-flop switches to a logical 1 level, and the next counting cycle begins.

3-61. The operations described in paragraphs 3-58 through 3-60 are the same for RESOLUTION kHz switch settings of 10 or 1. In the 10 position of the switch, +5 volt DC operating voltage is disconnected from 6th digit LED display DS706, and the 6th digit LED display is blank. The output frequency display consists of five digits; three to the left of the decimal point, and two to the right. When the RESOLUTION kHz switch setting is changed from 10 to 1, +5 volt DC is applied to 6th digit LED display DS706, and one additional decimal value is displayed.

3-62. When the RESOLUTION kHz switch setting is changed from 1 to 0.1, one additional decimal place must be displayed on the output frequency indicator of the Model 102A. This is accomplished by increasing the gate time by a factor of 10, so that 10 times as many frequency pulses are counted, and shifting the decimal point in the output frequency display one place to the left. Because of the change in RESOLUTION kHz switch setting, a different pair of circuits in tri-state buffer IC510 is gated on, and the timing of the gate, strobe, and reset pulses is controlled by the output sig-

nals from decade counter IC508 instead of those from decade counter IC507. Since one additional decade counter is employed in the timing chain, the timing signal frequency is decreased by a factor of 10, and the period is increased by a factor of 10. Except for the change in input timing signals, the gate, strobe, and reset pulses are developed as described in the preceding paragraphs. In the 0.1 position of the RESOLUTION kHz switch, the decimal point in 2nd digit LED display DS702 is activated, the decimal point in the output frequency display is effectively shifted one place to the left, and the output frequency display includes four decimal digits.

3-63. To summarize frequency counter circuit operation, assume that the Model 102A is tuned to an output frequency of 91.8362 MHz, and the RESOLUTION kHz switch is set to 10. Because the FREQUENCY MHz switch is set to band 3 for this output frequency, the gate pulses developed in the frequency counter circuits have a duration of 20 milliseconds. The frequency counter input signal frequency, which is one-half the VFO frequency, is 45.9181 MHz. After prescaling (division by 10) the frequency of the signal applied to diode CR701 is 4.59181 MHz. With a gate interval of 20 milliseconds, 91,836 input pulses will be applied to the decade counters during the gate interval. When the LED displays are strobed on, the 2nd through 5th digit LED displays will provide a frequency indication of 91.83. (The decimal point of 3rd digit LED display DS703 is activated, and 6th digit LED display DS706 is blanked for a 10 kHz resolution.) The displayed frequency thus corresponds to the actual output frequency of the Model 102A.

3-64. When the RESOLUTION kHz switch setting is changed from 10 to 1, 6th digit LED display DS706 is activated. In all other respects, count operation is the same. When the LED displays are strobed on, the 2nd through 6th digit LED displays will provide an output frequency indication of 91.836.

3-65. When the RESOLUTION kHz switch setting is changed from 1 to 0.1, the gate pulse duration is changed from 20 milliseconds to 200 milliseconds. The number of signal frequency pulses counted during the gate interval is thus increased from 91,836 to 918,362, and the 1st through 6th digit LED displays will provide an output frequency indication of 91.8362. (The decimal point of 2nd digit LED display DS702 is activated through the RESOLUTION kHz switch.)

NOTE

If the output frequency of the Model 102A is 100 MHz or higher and a resolution of 0.1 kHz is selected, the number of signal pulses occuring during the gate interval exceeds the capacity of the decade counters and overflow results. The most significant digit of the output frequency is effectively shifted out of the LED displays, and the LED displays will display only the six least significant digits.

3-66. DETAILED THEORY OF OPERATION, POWER SUPPLY CIRCUITS.

(refer to schematic diagram)

3-67. The power supply circuits provide d-c operating power for all other circuits of the Model 102A. Regulated output voltages of +5 volts, −15 volts, and +15 volts are provided. The power supply circuits are designed to operate from either 115 volt or 230 volt a-c power sources.

3-68. Input a-c power is supplied to the primary windings of the power transformer through the POWER switch and line voltage switch. The line voltage switch connects the primary windings of the power transformer in series for operation from a 230 volt a-c power source, and in parallel for operation from a 115 volt a-c power source. The power supply circuits are protected against overload by the line fuse. The a-c voltages developed in the three secondary windings of the power transformer are applied to three similar rectifier-regulator circuits.

3-69. The 11 volt a-c output of the power transformer is rectified by bridge rectifier CR805. The resulting d-c voltage is filtered and then regulated by voltage regulator IC801 and series regulator Q801. The effective impedance of the series regulator is varied as required to compensate for any variations in the output voltage. Potentiometer R803 provides the means for adjusting the output voltage of the supply to the + 5 volt value.

3-70. The +15 volt and −15 volt supplies are identical, except for reversed output connections. Input to each supply consists of 20 volts a-c, supplied by separate secondary windings of the power transformer. The applied a-c is rectified by a bridge rectifier, filtered, and regulated by a silicon monolithic voltage regulator and a transistor series regulator. Potentiometers R806 and R809 provide means for adjusting the output voltages of the +15 volt and −15 volt supplies, respectively. The +15 volt supply also supplies an unregulated + 28 volt d-c output which is used to power the pilot light integrally mounted in the POWER switch.

SECTION IV

MAINTENANCE

4-1. GENERAL

4-2. This section contains maintenance and calibration instruction for the Model 102A. Included is a list of test equipment required for maintenance, symptomatic and systematic troubleshooting procedures designed to localize a malfunction to an individual subassembly or circuit, and alignment and adjustment instructions for restoring the Model 102A to proper operating conditon after repairs have been completed.

NOTE

For minimum performance tests of the Model 102A, refer to Section II of the instruction manual.

4-3. TEST EQUIPMENT REQUIRED.

4-4. Test equipment required for maintenance is listed in Table 4-1. Equipment of equivalent characteristics may be substituted for any item listed.

TABLE 4-1. TEST EQUIPMENT LIST

Item No.	Nomenclature	Model No.
1	Amplifier	Hewlett Packard 465A
2	Crystal-Controlled Sources	Boonton Electronics Corporation (500.0000 MHz and 100.0000 MHz)
3	Distortion Analyzer	Hewlett Packard 331A
4	Double Balanced Mixer	Hewlett Packard 10514A
5	FM-AM Signal Generator	Boonton Electronics Corporation 102A
6	Frequency Counter	Systron Donner 6052 (8 digit, option 11 time base)
7	Frequency Meter	Hewlett Packard 5210A
8	Microwattmeter	Boonton Electronics Corporation 42A
9	Audio Oscillator	Hewlett Packard 200CD
10	Oscilloscope	Tektronix 5103N
11	RF Millivoltmeter	Boonton Electronics Corporation 92A
12	Spectrum Analyzer	Systron Donner 751
13	Voltmeter	Weston 1240
14	Probe	Tektronix P6060-00

4-5. PRELIMINARY INSPECTION.

4-6. Visual Check. If equipment malfunction occurs. perform a visual check of the Model 102A before performing electrical tests. Visual checks often help to isolate the cause of the malfunction quickly and simply. Inspect the Model 102A for signs of damage caused by excessive shock or vibration, such as: broken leadwires, loose hardware and parts, and loose electrical connections. Then check for signs of overheating which may be caused by electrical short circuits, or accumulations of dirt and other foreign matter. Correct any problems discovered through the visual check. If trouble persists, proceed with electrical checks.

4-7. Power Supply Check. Improper operation of the Model 102A may be caused by incorrect DC operating voltages. Before proceeding with any other electrical checks, perform the power supply checks in accordance with Table 4-2.

WARNING

Line voltages up to 230 volts AC may be encountered in the power supply circuits. To protect against electrical shock, observe suitable precautions when connecting and disconnecting test equipment, or when making voltage measurements.

TABLE 4-2. POWER SUPPLY CHECK

Step	Procedure	Normal Indication
1	Set the Model 102A POWER switch to ON. Using voltmeter, Weston Model 1240, measure the DC voltage between terminal A (+) and terminal B (−) of the power supply printed circuit board.	+ 5 ± 0.1 volts DC
2	Using oscilloscope, Tektronix Model 5103N, measure the AC ripple voltage between terminals A and B of the power supply printed circuit board.	5 millivolts peak-to-peak or less
3	Using the voltmeter, measure the DC voltage, in sequence, between each of terminals E, F, and G (+) and terminal D (−) of the power supply printed circuit board.	+ 15 ± 0.2 volts DC
4	Using the oscilloscope, measure the AC ripple voltage between terminals E and D of the power supply printed circuit board.	3.0 millivolts peak-to-peak or less
5	Using the voltmeter, measure the DC voltage, in sequence, between each of terminals I, K, and L (−) and terminal J (+) of the power supply printed circuit board.	- 15 ± 0.2 volts DC
6	Using the oscilloscope, measure the AC ripple voltage between terminals I and J of the power supply printed circuit board.	2.0 millivolts peak-to-peak or less
7	Using the voltmeter, measure the DC voltage between terminal C (+) and terminal H (−) of the power supply printed circuit board.	28 volts DC (nominal)

4-8. MAJOR ASSEMBLY LOCATION.

4-9. See Figures 4-1 and 4-2 for the location of the major assemblies of the Model 102A.

4-10. TROUBLE LOCALIZATION.

NOTE

Logical trouble localization involves three major procedures: symptomatic troubleshooting, used to localize the cause of malfunction to a major circuit group; systematic troubleshooting within the affected circuit group, used to localize the cause of malfunction to a circuit or stage; and voltage and/or waveform measurements, used to isolate the defective part.

4-11. Symptomatic Troubleshooting. The versatility built into the Model 102A facilitates symptomatic troubleshooting. Various groups of circuits can be switched into or out of the operating chain through manipulation of the operating controls. Also, different circuit configuations are employed on each of the five output frequency bands. With a thorough understanding of the detailed block diagrams (Figures 3-2 through 3-7), it is possible to localize the cause of most malfunctions to one of the major circuit groups by manipulating the operating controls and observing the results. (Refer to Table 4-3.) When the cause of malfunction has been localized to a major circuit group, refer to the systematic troubleshooting chart for the affected circuit group.

TABLE 4-3. SYMPTOMATIC TROUBLESHOOTING CHART

Symptom	Probable Cause of Malfunction
No output on all frequency bands; output frequency indicator also inoperative	Defective frequency generating circuits. (Refer to Table 4-4.)
No output on all frequency bands; output frequency indicator operates normally	Defective output circuits. (Refer to Table 4-7.)
No output or low output on bands 1 and 2 only; output frequency indicator operates normally	Defective signal processing circuits (bands 1 and and 2). (Refer to Table 4-5.)
No output or low output on band 2 only; output frequency indicator operates normally	Defective signal processing circuits. (Refer to Table 4-5.) Defective output circuits. (Refer to Table 4-7.)
No output or low output on band 1 only; output frequency indicator inoperative on band 1 only	Defective signal processing circuits (bands 1 and 2). (Refer to Table 4-5.)
No output or low output on band 1 only; output frequency indicator operates normally	Defective signal processing circuits (bands 1 and 2). (Refer to Table 4-5.) Defective output circuits. (Refer to Table 4-7.)
No output or low output over portions of bands 1 and 2 only; output frequency indicator inoperative over same portions of bands	Defective signal processing circuits (bands 1 and 2). (Refer to Table 4-5.)
No output or low output on bands 4 and 5 only; output frequency indicator operates normally	Defective signal processing circuits (bands 3 through 5). (Refer to Table 4-6.)
No output or low output on only one of bands 3, 4, or 5; output frequency indicator operates normally	Defective signal processing circuits (bands 3 through 5). (Refer to Table 4-6.) Defective output circuits. (Refer to Table 4-7.)
No output or low output over only portions of any or all of bands 3, 4, and 5; output frequency indicator operates normally.	Defective signal processing circuits (bands 3 through 5). (Refer to Table 4-6.)

TABLE 4-3. SYMPTOMATIC TROUBLESHOOTING CHART (Cont)

Symptom	Probable Cause of Malfunction
Output level varies excessively as band and/or output frequency is changed.	Defective output circuits. (Refer to Table 4-7.)
OUTPUT LEVEL meter indication is normal, but no output available at OUTPUT connector.	Defective output circuits. (Refer to Table 4-7.) **NOTE** If Model 102A incorporates option 04, r-f fuse could be defective.
No AM; OUTPUT control ineffective in control of output level.	Defective output circuits. (Refer to Table 4-7.)
AM operation normal; no FM	Defective modulation circuits. (Refer to Table 4-8.) Defective frequency generating circuits. (Refer to Table 4-4.)
FM operation normal; no AM; OUTPUT control operates normally.	Defective modulation circuits. (Refer to Table 4-8.)
External modulation normal; no internal modulation	Defective modulation circuits. (Refer to Table 4-8.)
Output normal on all bands, but output frequency indicator display incorrect or erratic.	Defective frequency counter circuits. (Refer to Table 4-9.)
Output frequency indicator display incorrect or erratic for one or more positions of RESOLUTION kHz switch; output normal.	Defective frequency counter circuits. (Refer to Table 4-9.)

4-12. Systematic Troubleshooting. When the cause of an equipment malfunction has been localized to a major group of circuits, refer to the appropriate systematic troubleshooting chart (Tables 4-4 through 4-9). The systematic troubleshooting charts provide instructions for further localization of the cause of the malfunction to a stage or circuit within the major circuit group. When the cause of the malfunction has been localized to a particular stage or circuit, isolate the defective part through voltage and/or waveform measurements. Refer to paragraph 4-31 for typical voltage data. Waveform data is included on the appropriate schematic diagrams. (See Figures 6-1 through 6-11.)

NOTE

Unless otherwise indicated, all voltage values given in Tables 4-4 through 4-9 are nominal values; also, all voltages are measured with reference to ground.

TABLE 4-4. SYSTEMATIC TROUBLESHOOTING CHART, FREQUENCY GENERATING CIRCUITS

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
1	Remove cover shields from top of r-f housing. Set POWER switch to ON, and TUNING control to fully counterclockwise setting, Using r-f millivoltmeter, Boonton Electronics Corp. Model 92A	0.3 volt rms (nominal)	Proceed to step 2.	Isolate defective part in VFO circuit through voltage measurements. Check VERNIER control and associated circuitry on meter and level adjust printed circuit board.

TABLE 4-4. SYSTEMATIC TROUBLESHOOTING CHART, FREQUENCY GENERATING CIRCUITS (Cont)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
	with probe, Model 91-12F, and probe tip, Model 91-13B, measure r-f signal level at terminal I of r-f housing.			
2	Using same test equipment as in step 1, measure r-f signal levels at junction of transformer T202 and resistor R210, and at junction of transformer T202 and resistor R214 on HF doubler and filter printed circuit board.	1.0 volt rms (nominal at both measurement points.	Frequency generating circuits are functioning normally.	Isolate defective part in buffer amplifier Q202 circuit through voltage measurements.

TABLE 4-5. SYSTEMATIC TROUBLESHOOTING CHART, SIGNAL PROCESSING CIRCUITS (BANDS 1 AND 2)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
1	Remove cover shields from r-f housing. Set FREQUENCY MHz switch to 32.5—65 (band 2), TUNING control approximately to mid-range, and POWER switch to ON. Using r-f millivoltmeter, Boonton Electronics Corporation Model 92A, with r-f probe, Model 91-12F, and probe tip, Model 91-13B, measure r-f signal level at terminal K of divider and converter printed circuit board.	0.7 volt rms (nominal)	Proceed to step 2.	Isolate defective part in isolation amplifer Q201, Q203, Q204, Q205 circuits through voltage measurements.
2	Using same test equipment and control settings as in step 1, measure r-f signal level at terminal E of divider and converter printed circuit board.	0.07 volt rms (nominal)	Proceed to step 4.	Check diodes CR404 through CR 407. Proceed to step 3.
3	Using same test equipment and control settings as in step 1, measure r-f signal at terminal F of divider and converter printed circuit board.	0.2 volt rms (nominal)	Proceed to step 4.	Isolate defective part in binary divider Q408-Q409 circuit through voltage measurements.

TABLE 4-5. SYSTEMATIC TROUBLESHOOTING CHART, SIGNAL PROCESSING CIRCUITS (BANDS 1 AND 2) — (Cont)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
4	Using voltmeter, Weston Model 1240, measure DC voltage at terminal D of divider and converter printed circuit board as TUNING control is rotated over entire tuning range.	+ 15 volts DC over lower portion of tuning range; – 15 volts DC over upper portion	If DC voltage is normal but indication for step 2 is still abnormal, isolate defective part in 0-47 MHz and 0-68 MHz filters and associated diode switch circuitry on divider and converter printed circuit board.	Check cam-operated switch S11 on main frame, filter FL1003 and switch section S1001G in r-f housing, and capacitors C417 and C418 on divider and converter printed circuit board.
5	Set FREQUENCY MHz switch to 4.3—37.5 (band 1). Using same test equipment as in step 1, measure r-f signal level at terminal C of divider and converter printed circuit board.	0.05 volt rms (nominal)	Proceed to step 8.	Proceed to step 6.
6	Using same test equipment as in step 1, measure r-f signal level at terminal M of divider and converter printed circuit board.	0.07 volt rms (nominal)	Proceed to step 7.	Check switch section S1001A in r-f housing.
7	Using voltmeter, Weston Model 1240, measure DC voltage at terminal A of divider and converter printed circuit board.	+ 15 volts DC	Isolate defective part in crystal oscillator Q414, mixer Z401, or dual amplifier Q410-Q411 circuit through voltage measurements.	Check filter FL1008, capacitors C1003 and C1004, and switch section S1001B in r-f housing; check capacitors C450, C451, C453, and C454 on divider and converter printed circuit board.
8	Using same test equipment as in step 1, measure r-f signal level at terminal B of divider and converter printed circuit board.	0.1 volt rms (nominal)	Signal processing circuits (bands 1 and 2) are operating normally	Isolate defective part in dual amplifier Q412-Q413 through voltage measurements.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART, SIGNAL PROCESSING CIRCUITS (BANDS 3 THROUGH 5)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
1	Remove cover shields from r-f housing. Set FREQUENCY MHz switch to 65—130 (band 3) and POWER switch to ON. Using r-f millivoltmeter, Boonton Electronics Corporation Model 92A, with r-f probe, Model 91-12F, and probe tip, Model 91-13B (with short ground lead), measure r-f signal level at terminal D of HF doublers and filters printed circuit board while slowly rotating TUNING control over entire tuning range.	0.05 volt rms (nominal) at 100 MHz; approximately 0.05 volt rms over entire tuning range.	Proceed to step 5.	If abnormal over only lower or upper portion of tuning range, check appropriate filter (0-93 MHz or 0-135 MHz) and associated diode switch circuitry on HF doublers and filters printed circuit board; if abnormal over entire tuning range, proceed to step 2.
2	Using voltmeter, Weston Model 1240, measure DC voltage at terminal M of HF doublers and filters printed circuit board while rotating TUNING control.	+ 15 volts DC from 65 to 90 MHz; − 15 volts DC over remainder of band.	Proceed to step 3.	Check cam-operated switch S11 on main frame, filter FL1003 and switch section S1001G in r-f housing.
3	Using same test equipment as in step 1, measure r-f signal level at junction of diodes CR204 and CR207 on HF doublers and filters printed circuit board.	Approximately 0.5 volt rms	Proceed to step 4.	Check diode switches CR202, CR203, CR205, and CR206, 0-93 MHz and 0-135 MHz filters, and associated circuitry on HF doublers and filters printed circuit board.
4	Using voltmeter, Weston Model 1240, measure DC voltage at terminal E of HF doublers and filters printed circuit board.	+ 15 volts DC	Check diode switch CR204 and associated circuitry.	Check filter FL1008, switch section S1001F, and capacitors C1001, C1003, and C1004 in r-f housing; check capacitors C225 and C226 on HF doublers and filters printed circuit board.
5	Set FREQUENCY MHz switch to 130—260 (band 4). Using same test equipment as in step 1, measure r-f signal level at terminal I of HF doublers and filters printed circuit board, while slowly rotating TUNING control over entire tuning range.	0.07 volt rms (nominal at 200 MHz; approximately 0.07 volt rms over entire tuning range.	Proceed to step 14.	If abnormal over only frequency range of 130 to 157.5 MHz, 157.5 to 205.0 MHz, or 205.0 to 260.0 MHz, proceed to step 6, 7 or 8, respectively; if abnormal over entire tuning range, proceed to step 9.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART, SIGNAL PROCESSING CIRCUITS (BANDS 3 THROUGH 5) — (Cont)

Step	Procedure	Normal Indication	If Indication is Normal	Is Indication is Abnormal
6	Using voltmeter, Weston Model 1240, measure DC voltage at terminal L of of HF doublers and filters printed circuit board while rotating TUNING control.	– 15 volts DC over frequency range of 130.0 to 157.5 MHz; 0 volt DC at all other frequencies.	Check diode switches CR209, and CR213, 130 to 158 MHz filter, and associated circuitry on HF doublers and filters printed circuit board.	Check filter FL1004 in r-f housing; cam-operated switch S10 in main frame; capacitors C301 and C308 on band 5 filters and switches printed circuit board.
7	Using voltmeter, Weston Model 1240, measure DC voltage at terminal G of HF doublers and filters printed circuit board while rotating TUNING control.	– 15 volts DC over frequency range of 157.5 to 205.0 MHz; 0 volt DC at all other frequencies.	Check diode switches CR210 and CR214, 158 to 205 MHz filter, and associated circuitry on HF doublers and filters printed circuit board.	Check filter FL1001 in r-f housing; cam-operated switches S10 and S9 in main frame; capacitor C306 on band 5 filters and switches printed circuit board.
8	Using voltmeter, Weston Model 1240, measure DC voltage at terminal F of HF doublers and filters printed circuit board while rotating TUNING control.	– 15 volts DC over frequency range of 205.0 to 260.0 MHz; 0 volt DC at all other frequencies.	Check diode switches CR211 and CR212, 205 to 260 MHz filter, and associated circuitry on HF doublers and filters printed circuit board.	Check filter FL1002 in r-f housing; cam-operated switch S9 in main frame; capacitor C307 on band 5 filters and switches printed circuit board.
9	Using voltmeter, Weston Model 1240, measure DC voltage at terminal E of HF doublers and filters printed circuit board.	– 15 volts DC	Proceed to step 10.	Check filter FL1010, capacitor C1005, and switch section S1001E in r-f housing.
10	Using voltmeter, Weston Model 1240, measure DC voltage at terminal H of HF doublers and filters printed circuit board.	+ 15 volts DC	Proceed to step 11.	Check switch section S1001E in r-f housing; capacitors C255, C256, and C257 on HF doublers and filters printed circuit board.
11	Using same test equipment as in step 1, measure r-f signal level at junction of resistor R227 and capacitor C227 on HF doublers and filters printed circuit board.	Approximately 0.5 volt rms	Proceed to step 12.	Check diode switch CR207 and associated circuitry on HF doublers and filters printed circuit board.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART, SIGNAL PROCESSING CIRCUITS (BANDS 3 THROUGH 5) — (Cont)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
12	Using same test equipment as in step 1, measure r-f signal level at junction of capacitor C229 and resistor R229 on HF doublers and filters printed circuit board.	0.15 volt rms (nominal)	Proceed to step 13.	Isolate defective part in first doubler CR208A - CR208B circuit on HF doublers and filters printed circuit board.
13	Using same test equipment as in step 1, measure r-f signal level at junction of diode switches CR215 and CR216 on HF doublers and filters printed circuit board.	Approximately 0.07 volt rms	Check diode switch CR215 and associated circuitry on HF doublers and filters printed circuit board.	Check high-pass filter and associated circuitry on HF doublers and filters printed circuit board.
14	Set FREQUENCY MHz switch to 260—520 (band 5). Using same test equipment as in step 1, measure r-f signal level at terminal A of band 5 filters and switches printed circuit board.	0.05 volt rms (nominal at 400 MHz; approximately 0.05 volt rms over remainder of band.	Signal processing circuits (bands 3 through 5) are operating normally.	If abnormal over entire band, proceed to step 15. If abnormal only over 260 to 315 MHz range, check diode switches CR301 and CR304, 240 to 320 MHz filter, and associated circuitry on band 5 filters and switches printed circuit board. If abnormal only over 315 to 410 MHz range, check diode switches CR302 and CR305, 300 to 420 MHz filter, and associated circuitry on band 5 filters and switches printed circuit board. If abnormal only over 410 to 520 MHz range, check diode switches CR303 and CR306, 400 to 540 MHz filter, and associated circuitry on band 5 filters and switches printed circuit board.
15	Using voltmeter, Weston Model 1240, measure DC voltages at terminal H and at terminal J on HF doublers and filters printed circuit board.	— 15 volts DC at each point	Proceed to step 16.	If abnormal at terminal H, check switch section S1001E in r-f housing; if abnormal at terminal J, check switch section S1001D in r-f housing.

TABLE 4-6. SYSTEMATIC TROUBLESHOOTING CHART, SIGNAL PROCESSING CIRCUITS (BANDS 3 THROUGH 5) — (Cont)

Step	Procedure	Normal Indication	If Indication is Normal	If Indication is Abnormal
16	Using TUNING control, adjust output frequency to 400 MHz. Measure r-f signal level at junction of transformer T206 and resistor R252 on HF doublers and filters printed circuit board, using same test equipment as in step 1.	0.5 volt rms (nominal)	Proceed to step 17.	Isolate defective part in diode switch CR216 circuit or band 5 driver Q206-Q207 circuit on HF doublers and filters printed circuit board through voltage measurements.
17	Using same test equipment as in step 1, measure r-f signal level at terminal K of HF doublers and filters printed circuit board.	0.15 volt rms (nominal)	Check capacitors C305 and C312 and associated circuitry on band 5 filters and switches printed circuit board.	Isolate defective part in 2nd doubler CR208C-CR208D circuit through voltage and resistance measurements.

TABLE 4-7. SYSTEMATIC TROUBLESHOOTING CHART, OUTPUT CIRCUITS

Step	Procedure	Normal Indication	If Indication Is Normal	If Indication is Abnormal
1	Set MODULATION function switch to CW and POWER switch to ON. Using r-f millivoltmeter, Boonton Electronics Corporation Model 92A, with r-f probe, Model 91-12F, and probe tip, Model 91-13B (with short ground lead), measure r-f signal level at terminal A of output amplifier and modulator printed circuit board for each position of FREQUENCY MHz switch.	Level adjustable to 1 volt rms, minimum, on each band, using OUTPUT control.	Proceed to step 4.	Proceed to step 2.
2	Using same test equipment as in step 1, measure r-f signal level at junction of diode switches CR601 through CR605 on output amplifier and modulator printed circuit board for each position of FREQUENCY MHz switch.	0.05 volt rms (nominal)	Proceed to step 3.	Check diode switch (CR601 through CR605) and associated circuitry on output amplifier and modulator printed circuit board for affected band; check filter FL1010 and switch section S1001C in r-f housing.

TABLE 4-7. SYSTEMATIC TROUBLESHOOTING CHART, OUTPUT CIRCUITS (Cont)

Step	Procedure	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
3	Temporarily connect jumper from junction of resistors R623 and R626 to ground. Using voltmeter, Weston Model 1240, measure DC voltage at terminal 6 of amplifier A602 on output amplifier and modulator printed circuit board.	DC voltage adjustable over range of +13 to −13 volts by means of OUTPUT control.	Isolate defective part in AM modulator or output amplifier A601 circuit on output amplifier and modulator printed circuit board through voltage measurements.	Isolate defective part in amplifier A602 circuit on output amplifier and modulator printed circuit board through voltage measurements.
4	Rotate OUTPUT control and note effect on OUTPUT LEVEL meter indication.	Meter pointer adjustable over full scale.	Proceed to step 5.	Isolate defective part in diode demodulator CR611 circuit on output amplifier and modulator printed circuit board, or in OUTPUT LEVEL meter circuit on meter and level adjust printed circuit board.
5	Set FREQUENCY MHz switch successively to each of its five positions. For each position, tune slowly across the band, using TUNING control, and note effect on OUTPUT LEVEL meter indication.	Meter indication remains constant within ± 0.5 dB	Proceed to step 6.	Isolate defective part in amplifier A602 circuit on output amplifier and modulator printed circuit board through voltage measurements.
6	Connect power detector of microwattmeter, Boonton Electronics Corporation Model 42A, to OUTPUT connector. Rotate OUTPUT LEVEL attenuator successively to each of its positions, and note indication on microwattmeter.	Microwattmeter indication corresponds to output level indicated by attenuator setting and OUTPUT LEVEL meter indication.	Proceed to step 7.	Check OUTPUT LEVEL attenuator. (If Model 102A is equipped with option 04, also check r-f fuse.)
7	Set MODULATION function switch to INT AM, METER switch to 100% AM, and MOD FREQ kHz switch to 0.4. Using AM control, position pointer of MODULATION meter to 50. Using	0.5 volts rms (nominal)	Output circuits are functioning normally.	Ascertain that modulation circuits are operating normally. Then, isolate defective part in amplifier A602, AM modulator, or diode demodulator CR611 circuit on output amplifier and modu-

TABLE 4-7. SYSTEMATIC TROUBLESHOOTING CHART, OUTPUT CIRCUITS (Cont)			
Step **Procedure**	**Normal Indication**	**If Indication Is Normal**	**Is Indication Is Abnormal**
OUTPUT control, position pointer of OUTPUT LEVEL meter to 0 dBm. Set function switch of distortion analyzer, Hewlett Packard Model 331A, to voltmeter position and measure a-f voltage at junction of resistors R623 and R626 on output amplifier and modulator printed circuit board with distortion analyzer.			lator printed circuit board through voltage measurements.

TABLE 4-8. SYSTEMATIC TROUBLESHOOTING CHART, MODULATION CIRCUITS			
Step **Procedure**	**Normal Indication**	**If Indication Is Normal**	**If Indication Is Abnormal**
FM PORTION			
1 Set FREQUENCY MHz switch to 4.3—37.5 (Band 1), MODULATION function switch to INT FM, MOD FREQ kHz switch to 0.4, DEVIATION kHz switch to 300, FM control fully clockwise, and POWER switch to ON. Set function switch of Hewlett Packard Model 331A distortion analyzer to voltmeter position, and measure a-f signal level at terminal B of VFO housing.	2.5 volts rms, (minimum)	Proceed to step 4.	Proceed to step 2.
2 Connect distortion analyzer to MOD FREQ OUT connector on rear panel. Rotate MOD FREQ kHz successively to each of its positions.	2.0 volts rms, minimum for each switch position	Check switch sections S1A, S1B, and S3B, FM control R14, and associated circuitry on main frame.	Proceed to step 3.
3 Using voltmeter, Weston Model 1240, measure DC voltages at terminals P501-J and P501-L of modulation oscillator, detector, and time base printed circuit board.	+15 volts at terminal P501-J; −15 volts at terminal P501-L.	Isolate defective part in modulation oscillator A501 or voltage follower Q501 circuit through voltage measurements.	Check switch sections S3C and S3D, respectively.

TABLE 4-8. SYSTEMATIC TROUBLESHOOTING CHART, MODULATION CIRCUITS (Cont)

Step	Procedure	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
4	Set FM control to produce 2.0 volts rms at terminal B of the VFO housing. Set FREQUENCY MHz switch successively to bands 2 through 5 and measure a-f signal amplitude at terminal B of VFO housing, using distortion analyzer.	2.0 volts rms, band 2; 1.0 volts rms, band 3; 0.5 volts rms, band 4; 0.25 volts rms, band 5 (nominal).	Proceed to step 5.	Check switch sections S1A through S1D and associated resistance networks (R1 through R6 and R8 through R10) on main frame.
5	Set FREQUENCY MHz switch to 4.3—37.5 (band 1). Set DEVIATION kHz switch successively to each of its positions, and measure a-f signal amplitude at terminal B of VFO housing, using distortion analyzer.	0.63 volt rms, 100 position; 0.2 volt rms, 30 position; 0.063 volt rms, 10 position; 0.02 volt rms, 3 position; (nominal).	Proceed to step 6.	Check switch sections S7C and S7D and associated resistance networks (R30 through R38) on main frame.
6	Set METER switch to FM and DEVIATION kHz switch to 100. Rotate FM control and observe effect on MODULATION meter.	MODULATION meter pointer adjustable to full scale.	Proceed to step 7.	If MODULATION meter operates normally for AM, check resistors R501 and R503, and potentiometer R502 on modulation oscillator, detector, and time base printed circuit board, and switch S2 on main frame. If MODULATION meter operation is abnormal for both FM and AM, check modulation detector A502-A503 and associated circuitry on modulation oscillator, detector, and time base printed circuit board, and switch S2, meter M1, and associated circuitry on main frame.
7	Set MODULATION function switch to EXT. Using audio oscillator, Hewlett Packard Model 200CD, apply a 1 kHz, 3-volt rms signal to EXT FM connector. Rotate FM control and observe effect on MODULATION meter. Then, set MODULATION function switch to INT AM, rotate FM control, and observe effect on MODULATION meter.	MODULATION meter pointer adjustable to full scale for both switch positions.	FM portion of modulation circuits is operating normally; if FM output of Model 102A is still not normal, check varactor circuits in VFO. Proceed to step 8 for AM portion trouble- shooting.	Check switch section S3B and associated circuitry on main frame.

TABLE 4-8. SYSTEMATIC TROUBLESHOOTING CHART, MODULATION CIRCUITS (Cont)

Step	Procedure	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
	AM PORTION			
8	Set MODULATION function switch to INT AM, and AM control fully clockwise. Using OUTPUT control, set pointer of OUTPUT LEVEL meter to 0 dBm. Using distortion analyzer, measure a-f signal level at wiper arm of OUTPUT control or at FL1007 on the r-f housing.	1.2 volts rms or more	Proceed to step 9.	Isolate defective part in audio amplifier Q901 and associated circuitry on meter and level adjust printed circuit board through voltage measurements; check switch section S3A, AM control R17, and associated circuitry on main frame.
9	With distortion analyzer connected as in step 8, adjust AM control as required to obtain 0.5 volt rms indication on distortion analyzer meter. Set METER switch to 100% AM and observe indication on MODULATION meter.	Approximately 50 on MODULATION meter	Proceed to step 10.	Check switch S2 and associated circuitry on main frame.
10	Set MODULATION function switch to EXT. Using audio oscillator, Hewlett Packard Model 200CD, apply a 1 kHz, 1-volt rms signal to AM connector. Set METER switch to 30% AM. Rotate AM control and observe effect on MODULATION meter. Then, set MODULATION function switch to INT FM, rotate AM control, and observe effect on MODULATION meter.	MODULATION meter pointer adjustable to full scale for both switch positions.	AM monitor portion of modulation circuits is operating normally; if AM output of Model 102A is still not normal, check output circuits.	Check switch section S3A and associated circuitry on main frame.

TABLE 4-9. SYSTMATIC TROUBLESHOOTING CHART, FREQUENCY COUNTER CIRCUITS

Step	Procedure	Normal Indication	Is Indication Is Normal	If Indication Is Abnormal
1	Using oscilloscope, Tektronix Model 531/53B, with probe, Model P6060-00, check signal waveform at	Waveform as shown in Figure 4-10.	Proceed to step 4.	Proceed to step 2.

Fig 6-10
PAGE -6-21/6-22

TABLE 4-9. SYSTEMATIC TROUBLESHOOTING CHART, FREQ. COUNTER CIRCUIT (Cont)

Step	Procedure	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
	pin 8 of IC 403 on divider and converter printed circuit board with FREQUENCY MHz switch set to 65—130 MHz and TUNING control turned down 6 turns from high frequency stop.			
2	Using r-f millivoltmeter, Boonton Electronics Corporation Model 92A with probe, Model 91-12F, and probe tip, Model 91-13B, measure r-f signal level at terminal H of divider and converter printed circuit board with FREQUENCY MHz switch set successively to each of its 5 positions.	0.1 volt rms (nominal on band 1); 0.2 volt rms (nominal on bands 2 through 5.)	Proceed to step 3.	Check switch section S1001H in r-f housing.
3	Set FREQUENCY MHz switch to 4.3—37.5 (band1) and TUNING control fully clockwise. Check waveform at terminal 1 of flip-flop IC401 on divider and converter printed circuit board, using same test equipment as in step 1.	Pulses with frequency of approximately 4 MHz.	Isolate defective part in ÷10 divider circuit on divider and converter printed circuit board through voltage measurements.	Isolate defective part in divider driver (Q401 through Q407) circuitry on divider and converter printed cir-board through voltage measurements.
4	Using same test equipment as in step 1, check signal waveform at terminal 8 of flip-flop IC506 on modulation oscillator, detector, and time base printed circuit board with FREQUENCY MHz switch set successively to each of its 5 positions. Set RESOLUTION switch to 1 kHz.	Waveform as shown in Figure 6-3; pulses with durations of 10, 10, 20, 40 and 80 milliseconds, respectively for bands 1 through 5.	Proceed to step 8.	Proceed to step 5.
5	Using same test equipment as in step 1, check waveform at test point TP1 on modulation oscillator, detector, and time base printed circuit board.	Waveform as shown in Figure 6-3.	Proceed to step 6.	Isolate defective part in 1 MHz crystal oscillator IC501 circuit on modulation oscillator, detector, and time base printed circuit board through voltage measurements.

TABLE 4-9. SYSTEMATIC TROUBLESHOOTING CHART, FREQ. COUNTER CIRCUIT (Cont)

Step	Procedure	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
6	Using same test equipment as in step 1, check waveform at terminals 8 and 11 of decade counter IC507 on modulation oscillator, detector, and time base printed circuit board. (Set RESOLUTION switch to 1 kHz.)	Pulse outputs at both points with frequency of 100, 100, 50, 25, or 12.5 Hz for bands 1 through 5 respectively.	Proceed to step 7.	If abnormal for one band, check switch section S7A on main frame; if abnormal for all bands, isolate defective decade counter (IC502, IC504, IC505, or IC507) on modulation oscillator, detector, and time base printed circuit board by checking output waveforms and voltage measurements.
7	With FREQUENCY MHz switch set to 4.3—37.5 (band 1), check signal waveform at terminal 12 of flip-flop IC506 on modulation oscillator, detector, and time base printed circuit board, using same test equipment as in step 1.	100 Hz pulses	Isolate defective part in circuit of flip-flop IC506 through voltage measurements.	Isolate defective part in tri-state buffer IC510 circuit on modulation oscillator, detector, and time base printed circuit board through voltage measurements; also, check switch S8 and associciated circuitry on main frame.
8	Using same test equipment as in step 1, check signal waveform at collector of transistor Q502 on modulation oscillator, detector, and time base printed circuit board.	Waveform as shown in Figure 6-3.	Proceed to step 10.	Proceed to step 9.
9	Using same test equipment as in step 1, check signal waveform at terminal 2 of dual driver IC509 on modulation oscillator, detector, and time base printed circuit board. (Set FREQUENCY MHz control to 65—130 and RESOLUTION kHz switch to 1 kHz.	Waveform as shown in Figure 6-3.	Isolate defective part in dual driver IC509 or amplifier Q502 circuit through voltage measurements.	Isolate defective part in tri-state buffer IC510 circuit on modulation oscillator, detector, and time base printed circuit board through voltage measurements.
10	Using same test equipment as in step 1, check signal waveform at terminal 10 of dual driver IC509 on modulation oscillator, detector, and time base printed circuit board.	Waveform as shown in Figure 6-3.	Proceed to step 11.	Isolate defective part in dual driver IC509 circuitry on modulation oscillator, detector, and time base printed circuit board through voltage measurements.

TABLE 4-9. SYSTEMATIC TROUBLESHOOTING CHART, FREQ. COUNTER CIRCUIT (Cont)

Step	Procedure	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
11	With FREQUENCY MHz switch set to 4.3—37.5 (band 1), set RESOLUTION kHz switch to 0.1 and check signal waveform at terminal 8 of flip-flop IC506 on modulation oscillator, detector, and time base printed circuit board.	Waveform as shown in Figure 6-3; pulse duration, 100 milliseconds.	If normal, but output frequency indicator of Model 102A still does not function normally, isolate defective part on counter and display printed circuit board through voltage measurements.	Isolate defective part in circuitry of tri-state buffer IC510 or decade counter IC509 on modulation oscillator, detector, and time base printed circuit board through voltage measurements; also, check switch S8 and associated circuitry on main frame.

4-13. ALIGNMENT AND ADJUSTMENT PROCEDURES.

4-14. General. Paragraphs 4-15 through 4-25 provide instructions for all alignments and adjustments required. Alignment or adjustment is not a substitute for troubleshooting; make certain that all other possible causes of equipment malfunction have been eliminated before undertaking alignment or adjustment. Also, make certain that all required test equipment is available. See Figures 4-1 and 4-2 for the location of alignment and adjustment controls.

4-15. Test Equipment Required. Items 1 through 13 of Table 4-1 are required for complete alignment and adjustment of the Model 102A. Test equipment having equivalent performance characteristics may be substituted for any item.

4-16. Power Supply Adjustments. To adjust the output voltages of the power supply, proceed as follows:

a. Ascertain that the Model 102A is disconnected from the AC power source. Disconnect the leadwires from terminals A, E, F, G, I, K, and L of the power supply printed circuit board. Tag the leadwires to facilitate reconnection.

b. Connect voltmeter, Weston Model 1240, between terminal A (+) and terminal B (–) of the power supply printed circuit board. Connect the Model 102A to the AC power source and set the POWER switch to ON. Adjust potentiometer R803 as required to obtain an indication of 5.00 ± 0.02 volts DC on the voltmeter.

c. Connect the voltmeter between terminal E (+) and terminal H (–) of the power supply printed circuit board. Adjust potentiometer R806 as required to obtain an indication of + 15.00 ± 0.05 volts DC on the voltmeter.

d. Connect the voltmeter between terminal I (–) and terminal H (+) of the power supply printed circuit board. Adjust potentiometer R809 as required to obtain an indication of – 15.00 ± 0.05 volts DC on the voltmeter.

e. Set the POWER switch to OFF, disconnect the Model 102A from the AC power source, and reconnect the leadwires disconnected in step a to the appropriate terminals of the power supply printed circuit board.

4-17. Modulation Oscillator Amplitude Adjustment. To adjust the amplitude of the internally generated modulation signal, proceed as follows:

a. Connect a 604 ohm resistor across the input terminals of distortion analyzer, Hewlett Packard Model 331A. Connect a cable between the MOD FREQ OUT connector on the rear panel of the Model 102A and the input terminals of the distortion anlayzer.

b. Set the function switch on the distortion analyzer to the voltmeter position. Set the MODULATION function switch on the Model 102A to INT FM.

c. Set the MOD FREQ kHz switch to 1. Adjust potentiometer R505 on the modulation oscillator, detector, and time base printed circuit board as required to obtain an indication of 1.25 volts rms on the distortion analyzer meter.

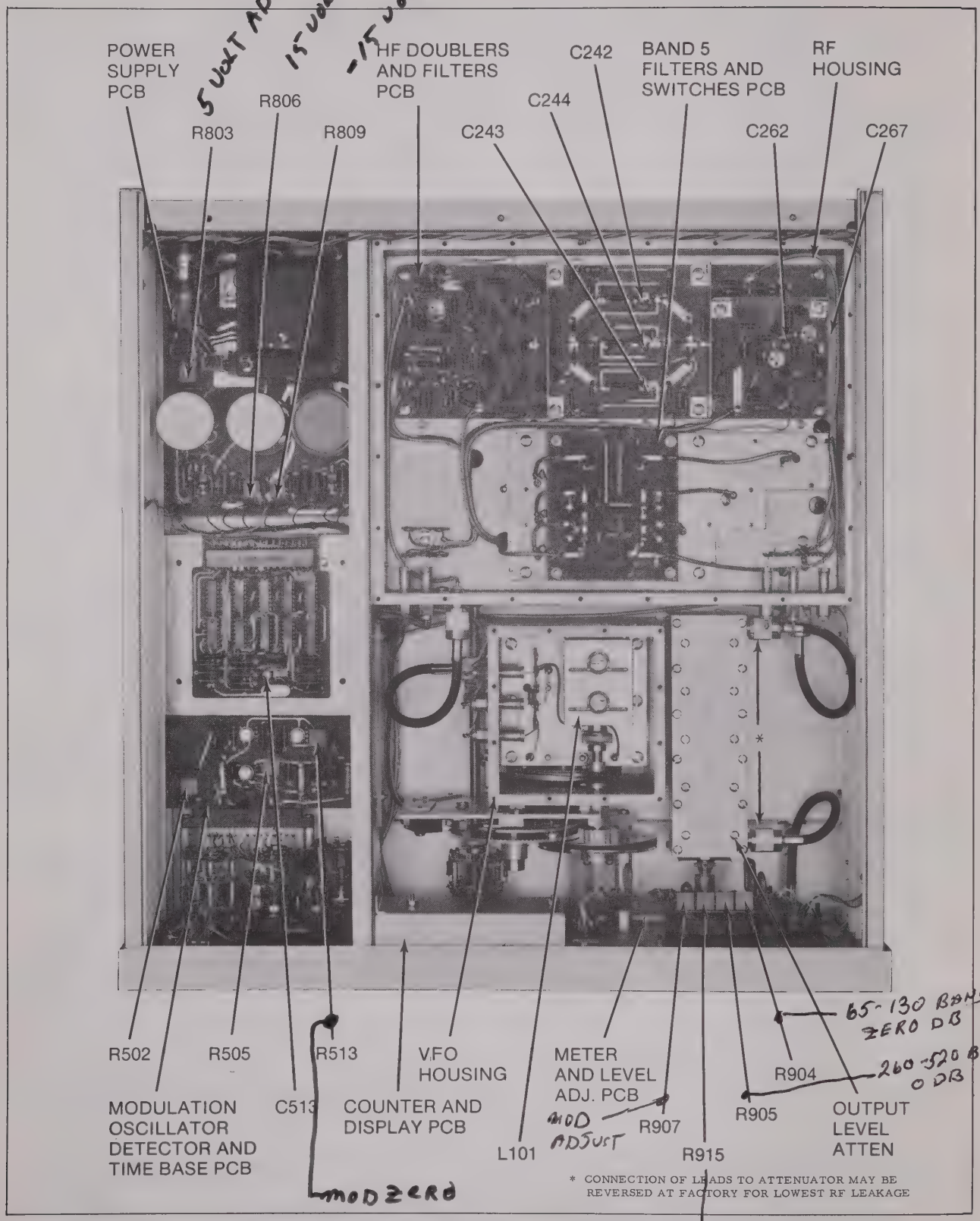


Figure 4-1 Model 102A, Top View with Cover Shields Removed

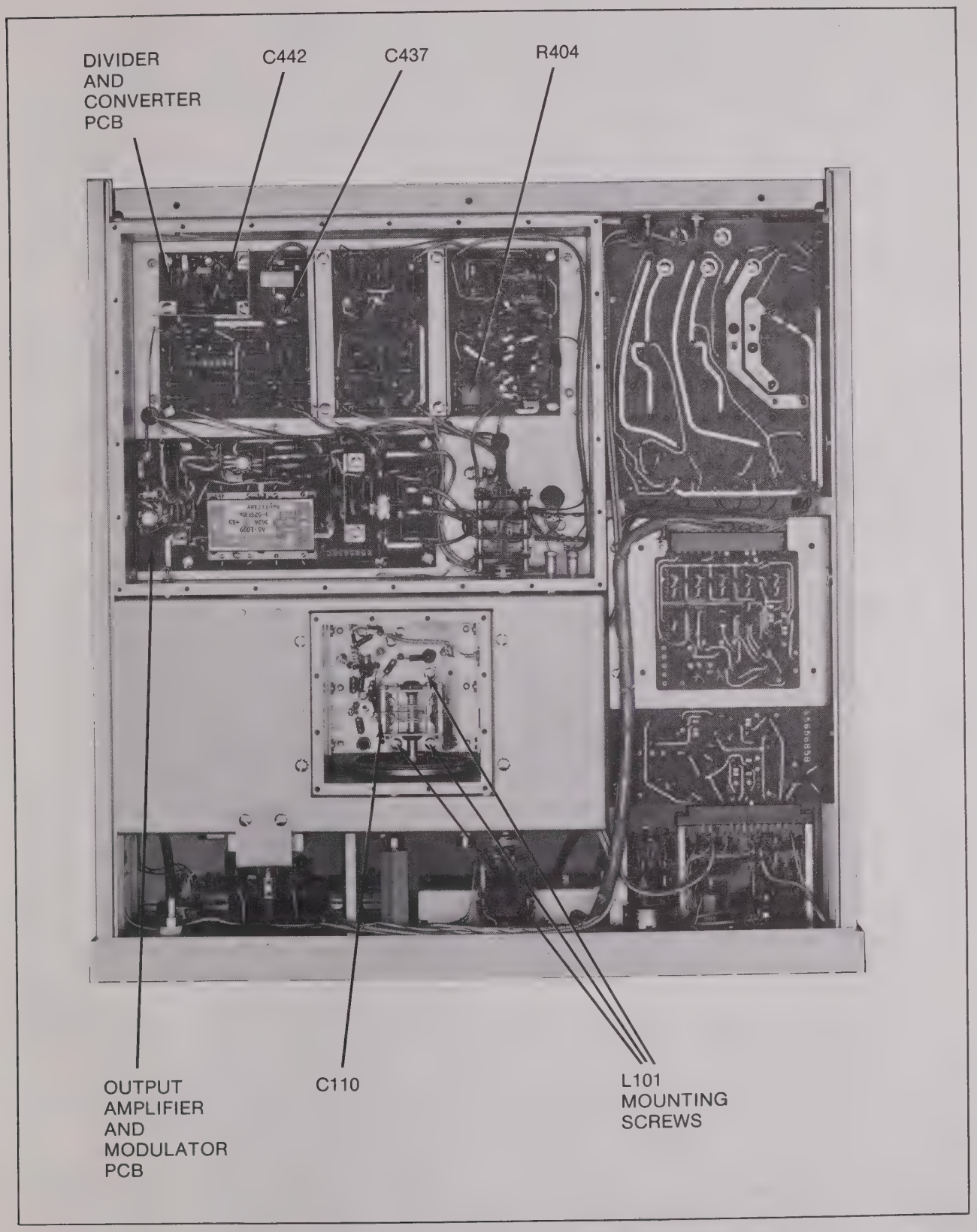


Figure 4-2 Model 102A, Bottom View with Cover Shields Removed

d. Set the MOD FREQ kHz switch successively to 0.4, 3, 10, and 19, and note the indication on the distortion analyzer meter for each switch position. The meter indication should be 1.15 volts rms or greater for each of the specified switch positions.

4-18. Counter Amplifier Gain Adjustment. To adjust the gain of the divider driver amplifier in the frequency counter circuits, proceed as follows:

a. Set the FREQUENCY MHz switch on the Model 102A to 32.5 — 65 (band 2), the MODULATION function switch to CW, and the RESOLUTION kHz switch to 1.

b. Rotate the TUNING control clockwise until the stop at the high-frequency end of the tuning range is encountered.

c. Adjust potentiometer R404 on the divider and converter printed circuit board through its entire range, and note the points at which the output frequency indicator display becomes erratic or incorrect. (The correct output frequency indicator display is approximately 66.000 MHz.)

d. Set potentiometer R404 midway between the points noted in preceding step c.

e. Rotate the TUNING control slowly counterclockwise to the low-frequency end of the tuning range while observing the output frequency indicator display. The output frequency indicator display should be stable and correct throughout the tuning range.

f. Set the FREQUENCY MHz switch to 4.3—37.5 (band 1). Rotate the TUNING control slowly through the entire tuning range and ascertain that the output frequency indicator display is stable and correct throughout the tuning range.

4-19. Clock Frequency Adjustment. To adjust the clock frequency for the frequency counter circuits, proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 4-3.

b. Set the Model 102A controls as follows:

Control	Position
DEVIATION kHz switch	300
MODULATION function switch	EXT FM
FREQUENCY MHz switch	260-520(band 5)
OUTPUT LEVEL attenuator	0 dBm
OUTPUT control	0 dBm on OUTPUT LEVEL meter
FM control	Fully clockwise
TUNING control	500.000 on output frequency indicator.

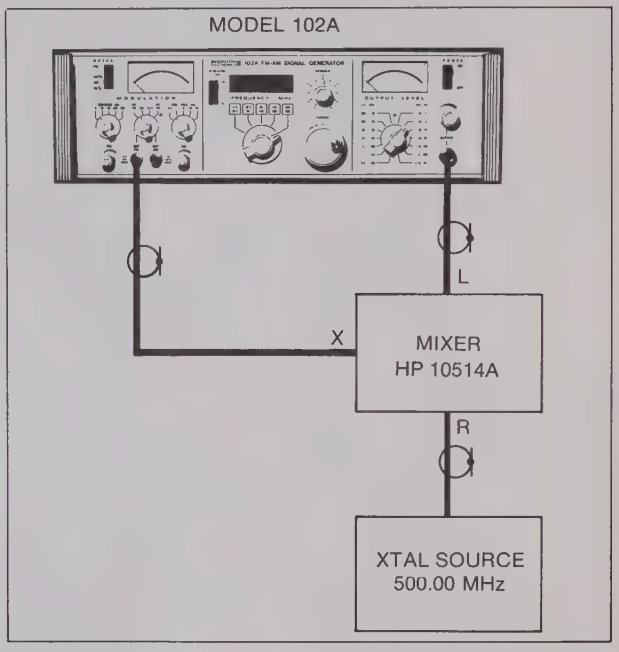


Figure 4-3 Clock Frequency Adjustment, Test Setup

c. Phase lock the Model 102A to the 500.000 MHz crystal oscillator by tuning slowly through 500.000 MHz, using the VERNIER control. (When phase lock is attained, the output frequency of the Model 102A will not change as the VERNIER control is rotated.)

d. Set the RESOLUTION kHz switch to 0.1. Adjust capacitor C513 on the divider and converter printed circuit board as required to obtain a display of 00.0000 on the output frequency indicator.

4-20. FM Deviation Tracking and Calibration. Proceed as follows:

a. Connect the Model 102A and test equipment as shown in Figure 4-4.

b. Set the *test* Model 102A controls as follows:

Control	Position
DEVIATION kHz switch	100
MODULATION function switch	EXT
FM control	Fully clockwise
FREQUENCY MHz switch	65—130 (band 3)
TUNING control	130.00 on output frequency indicator
OUTPUT LEVEL attenuator	0 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter
METER switch	FM

c. Set the *reference* Model 102A controls as follows:

Control	Position
MODULATION function switch	CW
FREQUENCY MHz switch	130—260(band 4)
OUTPUT LEVEL attenuator	+ 10 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter

d. Set potentiometer R502 on the modulation oscillator, detector, and time base printed circuit board to the fully clockwise position.

e. Adjust the output frequency of the audio oscillator to 1 kHz, as indicated on the frequency counter, and adjust the amplitude control of the audio oscillator as required to obtain a full-scale indication on the MODULATION meter of the *test* Model 102A.

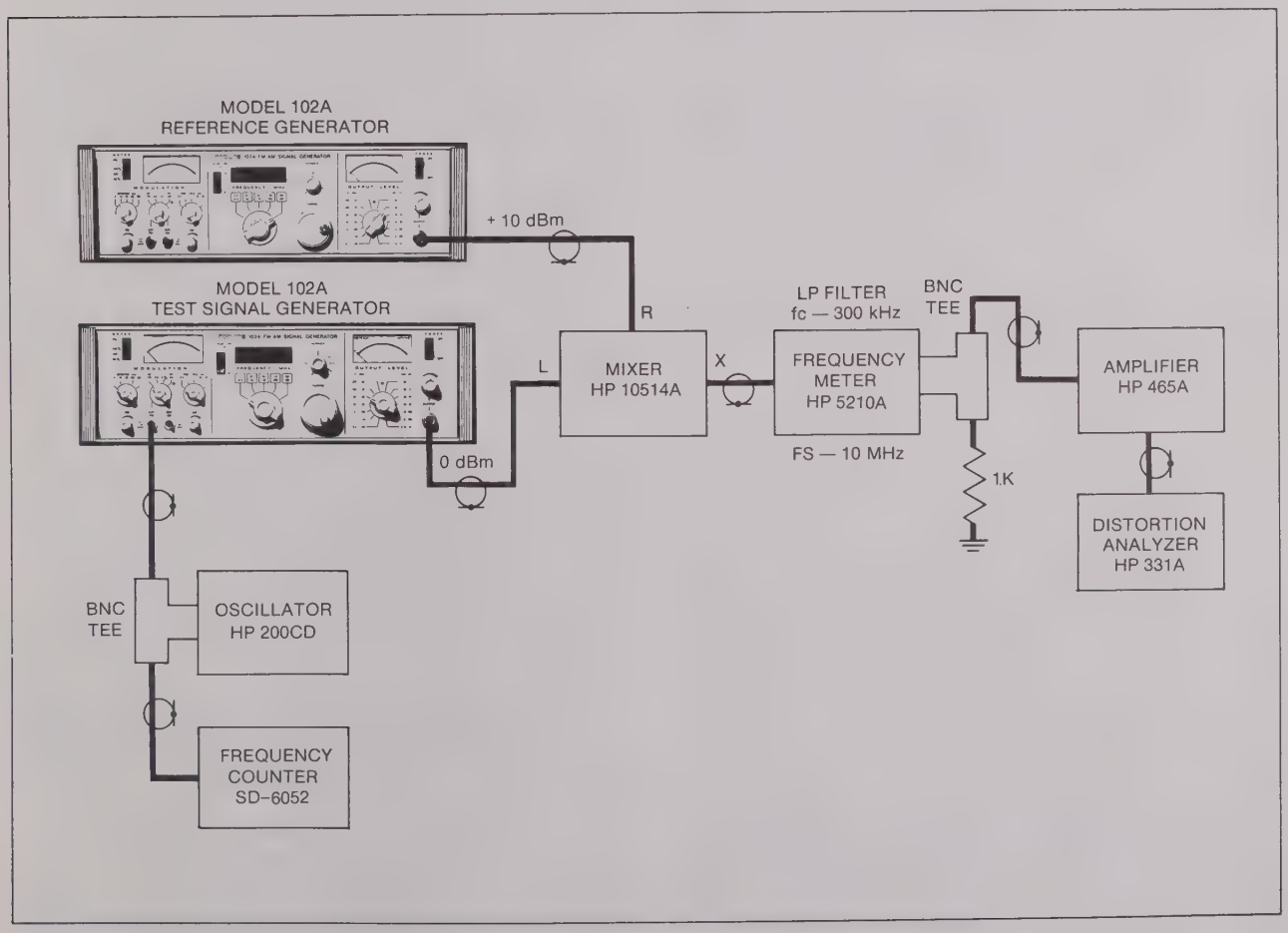


Figure 4-4 FM Deviation Tracking and Calibration, Test Setup

f. Tune the *reference* Model 102A to 138.00 MHz, using the TUNING control.

g. Set the function switch of the distortion analyzer to the set level position and the meter range switch to the 100 position. Adjust the sensitivity control on the distortion analyzer as required to obtain an indication of 0.8 on the distortion analyzer meter.

h. Adjust the four segmented rotor wafers at the high-frequency end of capacitor C110 uniformly for a spacing approximately twice that of the manufacturer's setting.

i. Decrease the output frequency of the *test* Model 102A and the *reference* Model 102A in 5 MHz decrements. (Make certain that the *reference* Model 102A output frequency is 8 MHz higher than that of the *test* Model 102A at each interval.) At each 5 MHz interval, adjust the rotor wafers of capacitor C110 uniformly as required to produce an indication of 0.80 ± 0.02 on the distortion analyzer meter.

j. Rotate the TUNING control of the *test* Model 102A slowly across the entire band, tracking the *reference* Model 102A 8 MHz above the *test* Model 102A output frequency at all points. Ascertain that the indication on the distortion analyzer meter is within the range of 0.78 to 0.82 at all points throughout the band. If necessary, readjust the segmented rotor wafers of capacitor C110 uniformly to obtain this indication.

k. Set the POWER switch on the *test* Model 102A to OFF. Using the adjusting screw of the MODULATION meter, position the meter pointer exactly at the zero mark on the meter dial.

l. Disconnect the mixer from the OUTPUT connector of the *test* Model 102A. Connect spectrum analyzer, Systron Donner Model 751, to the OUTPUT connector.

m. Set the POWER switch on the *test* Model 102A to ON, and the MODULATION function switch to CW. Using the TUNING control, adjust the output frequency to 100.00 MHz, as indicated on the output frequency indicator. Set the spectrum analyzer controls for a scan width of 10 kHz per centimeter and an i-f bandwidth of 1 kHz. Locate the 100.00 MHz signal on the spectrum analyzer display, and center the signal on the display.

n. Adjust potentiometer R513 on the modulation oscillator, detector, and time base printed circuit board as required to position on the pointer of the MODULATION meter on the *test* Model 102A exactly on the zero mark on the meter dial.

o. Set the MODULATION function switch on the *test* Model 102A to EXT. Adjust the output frequency of the audio oscillator to 41.58 kHz, as indicated on the frequency counter. Adjust the audio oscillator amplitude control from a minimum setting to the point where the carrier frequency signal on the spectrum analyzer display is at a null. Ascertain that the carrier frequency amplitude on the spectrum analyzer display is at least 40 dB below its unmodulated amplitude. Then, adjust potentiometer R502 on the modulation oscillator, detector, and time base printed circuit board as required to obtain a deviation indication of exactly 100 kHz on the MODULATION meter of the *test* Model 102A.

p. Set the MODULATION function switch on the *test* Model 102A to CW. Rotate the TUNING control slowly across the band and note the output frequency indication at the points where the microswitches on the VFO tuning mechanism are actuated. If necessary, readjust the microswitches to actuate at the following output frequencies: 78.75 ± 0.2 MHz, 90.00 ± 0.3 MHz, and 102.50 ± 0.3 MHz.

q. Rotate the TUNING control on the *test* Model 102A first to the low-frequency end of the band, then to the high-frequency end, noting the display on the output frequency indicator at the points where the mechanical end stops are encountered. The band end frequencies should be 63.8 ± 0.1 MHz and 132.3 ± 0.1 MHz. If necessary, readjust the end stops as required to obtain the specified band end frequencies.

4-21. Band-Pass Filter Alignment. To align the band-pass filters on the hf doublers and filters printed circuit board, proceed as follows:

a. Using the 50-ohm termination probe of r-f millivoltmeter, Boonton Electronics Corporation Model 92A, connect the r-f millivoltmeter to the OUTPUT connector of the Model 102A. Disable the automatic leveling loop of the Model 102A by connecting a clip lead from the junction of resistors R613 and R616 on the output amplifier and modulator printed circuit board to ground.

b. Set the FREQUENCY MHz switch to 130—260 (band 4), the OUTPUT LEVEL attenuator to 0 dBm, and the MODULATION function switch to CW.

c. While observing the indication on the r-f millivoltmeter, adjust the output frequency of the Model 102A slowly, using the TUNING control, from 130 MHz to the frequency at which the first microswitch on the VFO tuning mechanism is actuated (approximately

157.5 MHz). Adjust capacitor C242 as required to minimize variations in the r-f millivoltmeter indication over this tuning range.

d. While observing the indication on the r-f millivoltmeter, adjust the output frequency of the Model 102A slowly, using the TUNING control, from the point where the first microswitch was actuated in step c (approximately 157.5 MHz) to the point where the third microswitch is actuated (approximately 205.0 MHz). Adjust capacitor C244 as required to minimize variations in the r-f millivoltmeter over this tuning range.

e. While observing the indication on the r-f millivoltmeter, adjust the output frequency of the Model 102A slowly, using the TUNING control, from the point where the third microswitch was actuated in step d (approximately 205.0 MHz) to 260.0 MHz. Adjust capacitor C243 as required to minimize the variations in the r-f millivoltmeter indication over this tuning range.

f. Disconnect the clip lead connected in step a.

4-22. Band 5 Driver Adjustment. To adjust the band 5 driver on the hf doubler and filter printed circuit board, proceed as follows:

a. Using the 50-ohm termination probe of r-f millivoltmeter, Boonton Electronics Corporation Model 92A, connect the r-f millivoltmeter to the OUTPUT connector of the Model 102A. Disable the automatic leveling loop of the Model 102A by connecting a clip lead from the junction of resistors R613 and R616 on the output amplifier and modulator printed circuit board to ground.

b. Set the FREQUENCY MHz switch on the Model 102A to 260—520 (band 5), the OUTPUT LEVEL attenuator to 0 dBm, and the MODULATION function switch to CW.

c. Using the TUNING control, adjust the output frequency of the Model 102A to 520.0 MHz and note the indication on the r-f millivoltmeter. Adjust capacitors C262 and C267 as required to maximize the r-f millivoltmeter indication. Ascertain that this maximized indication is greater than +5 dBm.

d. Disconnect the clip lead connected in step a.

4-23. Band 1 Converter Alignment. To align the band 1 converter on the divider and converter printed circuit board, proceed as follows:

a. Connect spectrum analyzer, Systron Donner Model 751, to the OUTPUT connector of the Model 102A. Set the input attenuator of the spectrum analyzer to 20 dB.

b. Set the FREQUENCY MHz switch on the Model 102A to 4.3—37.5 (band 1). Set the TUNING control fully counterclockwise against the high-frequency stop.

c. Adjust capacitor C442 as required to obtain a strong signal indication at approximately 38 MHz on the spectrum analyzer display. Set the OUTPUT LEVEL attenuator on the Model 102A to 0 dBm and position the pointer of the OUTPUT LEVEL meter to the 0 dB mark, using the OUTPUT control.

d. Using the TUNING control, tune the Model 102A across band 1, noting the spurious mixing products (non-harmonics) on the spectrum analyzer display. Readjust capacitor C442 as required to minimize the spurious mixing products. Ascertain that the amplitude of the spurious mixing products is 30 dB or more below the main output signal amplitude.

e. Locate the 70 MHz local oscillator signal on the spectrum analyzer display. Adjust capacitor C437 as required to minimize the 70 MHz local oscillator signal on the spectrum analyzer display.

f. Repeat step d.

4-24. Output Level Calibration. To calibrate the output level circuits on the meter and level adjust printed circuit board, proceed as follows:

a. Set the POWER switch on the Model 102A to OFF. Using the adjusting screw, position the pointer of the OUTPUT LEVEL meter exactly on the zero mark.

b. Disconnect the r-f cable from the VFO at terminal 1 of the r-f housing. Set the POWER switch to ON, and adjust potentiometer R915 as required to position the pointer of the OUTPUT LEVEL meter exactly on the zero mark. Then, reconnect the r-f cable to terminal I of the r-f housing.

c. Connect the power detector of microwattmeter, Boonton Electronics Corporation Model 42A, to the OUTPUT connector of the Model 102A. Set the FREQUENCY MHz switch on the Model 102A to 65—130 (band 3), adjust the TUNING control as required to obtain an indication of 100.00 on the output frequency indicator, and set the OUTPUT LEVEL attenuator to 0 dBm.

d. Adjust the OUTPUT control as required to obtain an indication of exactly 0 dBm on the microwattmeter. Adjust potentiometer R904, if necessary, to obtain an indication of exactly 0 dB on the OUTPUT LEVEL meter.

e. Using the OUTPUT control, position the pointer of the OUTPUT LEVEL meter at the +3 dB mark. Tune across bands 1 through 4 of the Model 102A, and ascertain that the indication on the OUTPUT LEVEL meter remains within the range of +3 ±0.2 dBm throughout the tuning range of each of the four bands.

f. Set the FREQUENCY MHz switch to 260—520 (band 5), and adjust the TUNING control to obtain an indication of 365.00 on the output frequency indicator.

g. Adjust the OUTPUT control as required to obtain an indication of exactly 0 dBm on the microwattmeter. Adjust potentiometer R905 as required to obtain an indication of exactly 0 dB on the OUTPUT LEVEL meter.

h. Using the OUTPUT control, position the pointer of the OUTPUT LEVEL meter at the +3 dBm mark on the meter. Using the TUNING control, tune across the entire band and ascertain that the indication on the OUTPUT LEVEL meter remains within the limits of +3 ±0.2 dB over the entire tuning range.

4-25. AM Calibration. To calibrate the AM circuits on the meter and level adjust printed circuit board, proceed as follows:

a. Connect the Model 102A and the test equipment as shown in Figure 4-5.

b. Set the Model 102A controls as follows:

Control	Position
METER switch	100% AM
MODULATION function switch	INT AM
MOD FREQ kHz switch	1
FREQUENCY MHz switch	65—130 (band 3)
TUNING control	100.20 on output freqeuency indicator
OUTPUT LEVEL attenuator	−10 dBm
OUTPUT control	0 dB on OUTPUT LEVEL meter

c. Adjust the AM control as required to produce a trapezoid with an A dimension (Figure 4-5) of 8 divisions on the oscilloscope display and a B dimension of 2.65 divisions.

d. Adjust potentiometer R907 as required to obtain an indication of exactly 50 on the MODULATION meter.

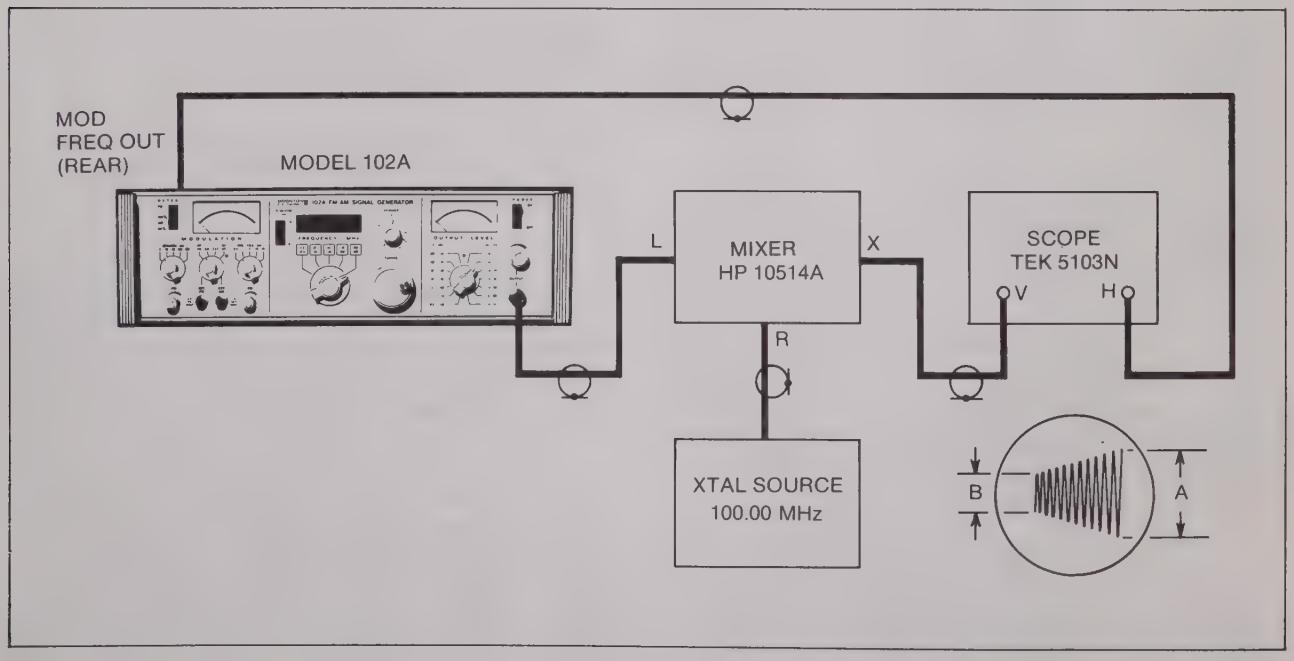


Figure 4-5 AM Calibration, Test Setup

e. Using the OUTPUT control, position the pointer of the OUTPUT LEVEL meter to the – 10 dBm mark on the meter. Adjust the oscilloscope sensitivity so that the A dimension of the trapezoid on the oscilloscope display is 8 divisions. Ascertain that the B dimension is 2.60 to 2.70 divisions. If the B dimension is not within these limits, replace resistor R918 with a resistor of a different value, as follows:

1. If the B dimension of the trapezoid is less than 2.60 divisions, decrease the resistance of resistor R918.

2. If the B dimension of the trapezoid is more than 2.70 divisions, increase the resistance of resistor R918.

f. If the value of resistor R918 had to be changed in preceding step e, repeat steps c through e.

4-26. PARTS REMOVAL.

4-27. General. Careful attention has been paid in the design of the Model 102A to maintainability. Most parts are readily accessible for checking and replacement when the case and cover shields are removed. Solid-state circuit components, mounted on printed circuit boards, are used throughout the equipment. Standard printed circuit board maintenance techniques are required for removal and replacement of parts. Excessive heat must be avoided; a low-wattage soldering iron and suitable heat sinks should be used for all soldering and unsoldering operations.

4-28. VFO Variable Inductor Removal. (See Figures 4-1 and 4-2.) Variable inductor L101 is mounted inside the VFO housing on the Model 102A chassis. To remove the variable inductor, proceed as follows.

a. Remove the shield covers from the top and bottom of the VFO housing.

b. Unsolder all leadwires from variable inductor L101.

c. Loosen the setscrews that attach the flexible coupling to the shaft of the variable inductor.

d. Remove the three screws that attach the variable inductor case to the chassis.

e. Press back the flexible coupling from the variable inductor shaft until the coupling clears the end of the shaft, and lift the variable inductor out of the VFO housing.

4-29. Tuning Control Drive, Dial Cord Replacement. The TUNING control drives the VFO tuning elements by means of a dial cord arrangement. If replacement of the dial cord becomes necessary, set the TUNING control fully counterclockwise against the stop and install the dial cord as shown in Figure 4-6. Use 0.028 inch diameter nylon dial cord, General Cement part number 75, or equivalent.

4-30. Varactor Tracking Capacitor, Dial Cord Replacement. Varactor tracking capacitor C110 is driven from the VFO variable inductor drive shaft by means of a dial cord arrangement. If replacement of a dial cord becomes necessary, proceed as follows:

a. Set the TUNING control to the middle of its tuning range.

b. Remove the shield covers from the top and bottom of the VFO housing.

c. Position the pulley on the shaft of capacitor C110 so that the slot in the pulley faces directly downward.

d. Install the replacement dial cord as shown in Figure 4-7. Use 0.028-inch diameter nylon dial cord, General Cement part number 75, or equivalent.

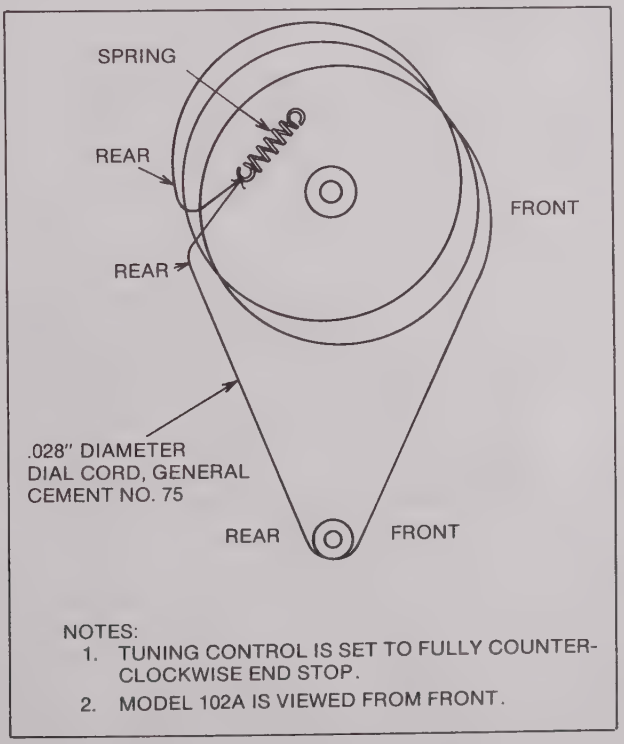


Figure 4-6 TUNING Control Drive, Dial Cord Installation

e. Rotate the TUNING control fully counterclockwise against the end stop. Verify that the rotor plates of capacitor C110 are ⅛ inch from full mesh. If necessary, loosen the setscrews in the capacitor drive pulley and rotate the capacitor shaft to achieve the specified degree of mesh; then, tighten the setscrews.

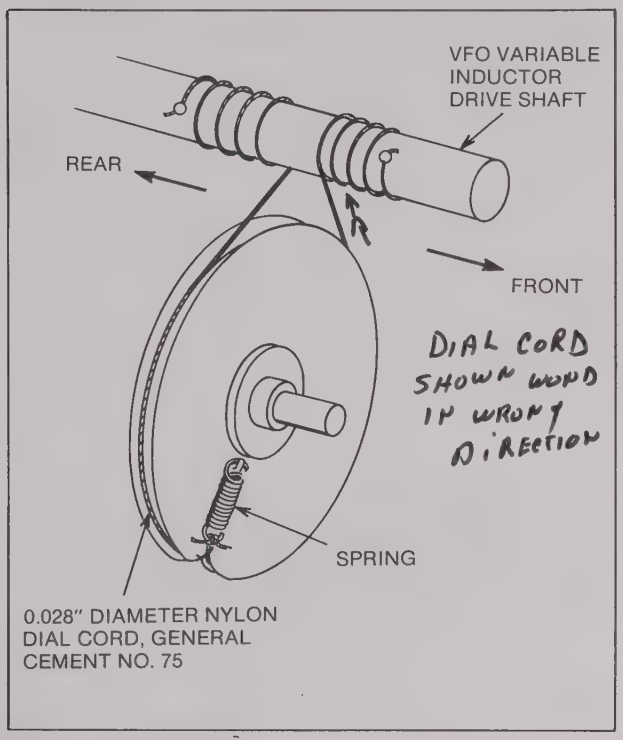


Figure 4-7 Varactor Tracking Capacitor, Dial Cord Installation

f. Check FM deviation tracking and calibration in accordance with paragraph 4-20.

4-31. VOLTAGE MEASUREMENTS.

4-32. Tables 4-10 through 4-15 list typical DC voltages at the terminals of transistors and integrated circuits. All voltage measurements were made using a Weston Model 1240 voltmeter. Unless otherwise indicated, all voltages are positive, and were measured with reference to chassis ground.

TABLE 4-10. DC VOLTAGES, HF DOUBLERS AND FILTERS PCB

Transistor	Terminal Voltages* E	B	C
Q201	−2.9	−3.7	−3.1
Q202	−9.8	−9.1	0.0
Q203	−6.5	−5.7	−3.7
Q204	−6.5	−6.8	−0.4
Q205	−1.7	−2.5	−6.8
Q206	−9.8	−9.1	0.0
Q207	−10.2	−9.4	0.0

*All voltage values were obtained under no-signal conditions.

TABLE 4-11. DC VOLTAGES, MODULATION OSCILLATOR, DETECTOR, AND TIME BASE PCB

Component	Terminal Voltage* E	B	C	1	2	3	4	5	6	7	8
Q501	0.8	0.1	15.0								
A501				10.9	0.0	0.0	−13.5	10.9	0.0	13.5	−12.2
A502				0.0	0.0	0.0	−15.0			15.0	15.0
A503				15.0	0.0	0.0	−15.0		15.0	15.0	15.0

*Voltage values for components A502 and A503 were obtained under no signal conditions; all other voltage values with normal signals.

TABLE 4-12. DC VOLTAGES, DIVIDER AND CONVERTER PCB

Terminal	Component Voltage*															
	Q401	Q402	Q403	Q404	Q405	Q406	Q407	Q408	Q409	Q410	Q411	Q412	Q413	IC401	IC402	IC403
S	1.7															
D	13.9															
G	0.0															
E		14.6	1.0	6.4	6.8	6.8	2.8	7.7	7.7	0.6	0.6	0.6	0.6			
B		13.9	1.7	7.0	6.4	6.0	3.6	7.3	7.3	1.3	1.3	1.3	1.3			
C		1.7	7.0	15.0	0.5	3.6	3.4	0.0	0.0	12.8	3.4	3.3	12.8			
1														1.9	0.0	0.0
2														5.0	5.0	5.0
3														5.0	5.0	1.4
4														5.0	5.0	1.5
5														1.7	5.0	5.0
6														1.7	2.5	2.9
7														2.1	0.0	0.0
8														0.0	1.5	0.8
9														1.5	5.0	5.0
10														5.0	5.0	5.0
11														2.9	5.0	5.0
12														5.0	1.4	1.7
13														1.7	5.0	5.0
14														5.0	5.0	5.0
15														5.0		
16														5.0		

*Voltage values for transistors Q401 through Q407 were obtained under no-signal conditions; all other voltage values, with normal signals.

TABLE 4-13. DC VOLTAGES, OUTPUT AMPLIFIER AND MODULATOR PCB

Component	Terminal Voltage*							
	1	2	3	4	5	6	7	8
A602	9.7	−1.6	−1.6	-14.9	-14.1	-5.6	14.6	10.5
A603	12.4	0.0	0.0	−15.0	12.4	5.0	14.6	−13.6

*All voltage values were obtained with Model 102A controls set for CW, output frequency of 100 MHz, and power level of +10 dBm.

TABLE 4-14. DC VOLTAGES, POWER SUPPLY PCB

	Terminal Voltage								
Component	**E**	**B**	**C**	**1**	**2**	**3**	**4**	**5**	**6**
Q801	5.7	6.4	12.3						
Q802	15.3	15.9	24.9						
Q803	0.3	0.9	9.8						
IC801				0.0	12.3	6.8	6.3	8.0	4.2
IC802				0.0	25.0	+ 15.9	15.5	17.1	4.2
IC803				−15.0	9.8	1.0	0.5	2.1	− 10.8

TABLE 4-15. DC VOLTAGES, METER AND LEVEL ADJUST PCB

	Terminal Voltage		
Component	**E**	**B**	**C**
Q901	4.3	3.2	−3.3

SECTION V

PARTS LIST

TABLE OF REPLACEABLE PARTS

Ref.	Description	Manufacturer's Part No.	BEC Part No.
	CAPACITORS		
*C1	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C2	Capacitor, Tant. 100 μF 10 V 20%	Sprague 196D107X0010LA3	283291
C3	Capacitor, Mica 3.1 mF 500 V 0.5%	G.I. RDM19FD312E03	200521
C4	Capacitor, Mica 3.1 mF 500 V 0.5%	G.I. RDM19FD312E03	200521
†C7	Capacitor, Cer. 5 pF ±0.25 pF, 500 V	Erie 301-000-COHO509C	220120
††C11	Capacitor, Cer. 5 pF ±0.25 pF 500 V	Erie 301-000-COHO509C	220120
☆C15	Capacitor, Cer. 5 nF 20% 500 V	RMC SM	224213
☆C16	Capacitor, Tant. 100 μF 20% 20V	Sprague 196D107X0020MA3	283292
☆C17	Capacitor, Tant. 100 μF 20% 20V	Sprague 196D107X0020MA3	283292
☆C18	Capacitor, Tant. 100 μF 20% 20V	Sprague 196D107X0020MA3	283292
C101	Capacitor, Mod. 470 pF (M/F 227110)	Boonton Electronics	227116
C102	Capacitor, FT 470 pF 500 V 20%	AB FA5C1-712	227112
C103	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C104	Capacitor, Cer. 8.2 pF 5% N470	Sprague CO35B10258R2D	224225
C105	Capacitor, Cer. 20 pF 500 V 5%	Erie 301	220114
C106	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C107	Capacitor, Cer. 15 pF 500 V 5%	Erie 301-000-COGO-150J	220126
C108	Capacitor, Cer. 160 pF 200 V 5%	MEPCO CV35NC161J	224205
C109	Capacitor, FT 470 pF 500 V 20%	A-B FA5C4712	227112
C110	Capacitor, Var. 3.5 – 18 pF	Jackson	275152
C111	Capacitor, FT 10 pF 500 V 10%	A-B FA5C-1001	227115
C201	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C202	Capacitor, Cer. 56 pF 150 V 20%	MEPCO CV15GC560M	224207
C203	Capacitor, Tant. 1.0 μF 35 V 20%	Sprague 196D105X9035HA1	283216
C204	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C205	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C206	Capacitor, Cer. 82 pF 150 V 20%	MEPCO CV15GC820M	224195
C207	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C208	Capacitor, Cer. 100 pF 200 V 5%	MEPCO CV35NC181J	224202
C209	Capacitor, Cer. 180 pF 200 V 5%	MEPCO CV25NC470J	224201
C210	Capacitor, Mica 68 pF 500 V 5%	ARCO DM15-680J	200031
C211	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C212	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C213	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C214	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C215	Capacitor, Cer. 47 pF 200 V 5%	MEPCO CV25NC470J	224200
C216	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C217	Capacitor, Cer. 75 pF 200 V 5%	MEPCO CV25NC750J	224197
C218	Capacitor, Cer. 56 pF 200 V 5%	MEPCO CV25NC560J	224193
C219	Capacitor, Cer. 75 pF 200 V 5%	MEPCO CV25NC750J	224197
C220	Capacitor, Cer. 56 pF 200 V 5%	MEPCO CV25NC560J	224193
C221	Capacitor, Cer. 47 pF 200 V 5%	MEPCO CV25NC470J	224200
C222	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C223	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C224	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C225	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C226	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C227	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C228	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C229	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C230	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C231	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C232	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C233	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C234	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C235	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C236	Capacitor, Cer. 82 pF 150 V 20%	MEPCO CV15GC820M	224195
C237	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C238	Capacitor, Cer. 43 pF 200 V 5%	MEPCO CV25NC430J	224223
C239	Capacitor, Cer. 27 pF 200 V 5%	MEPCO CV15NC270J	224196
C240	Capacitor, Cer. 36 pF 200 V 5%	MEPCO CV25NC360J	224198
C241	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C242	Capacitor, Var. 1.7-6 pF 250 V	Johansson 9300	281013
C243	Capacitor, Var. 1.7-6 pF 250 V	Johansson 9300	281013
C244	Capacitor, Var. 1.7-6 pF 250 V	Johansson 9300	281013
C245	Capacitor, Cer. 43 pF 200 V 5%	MEPCO CV25NC430J	224223
C246	Capacitor, Cer. 27 pF 200 V 5%	MEPCO CV15NC270J	224196
C247	Capacitor, Cer. 39 pF 200 V 5%	MEPCO CV25NC390J	224222
C248	Capacitor, Cer. 82 pF 150 V 20%	MEPCO CV15GC820M	224195
C249	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C250	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C251	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C252	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C253	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C254	Capacitor, Cer. 27 pF 200 V 5%	MEPCO CV15NC270J	224196
C255	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C256	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C257	Capacitor, Cer. 27 pF 200 V 5%	MEPCO CV15NC270J	224196
C258	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C259	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C260	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C261	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C262	Capacitor, Var. 3.2-18 pF 250 V	Johansson 9313	281011
C263	Capacitor, Cer. 30 pF 200 V 5%	MEPCO CV20COG300J	224204
C264	Capacitor, Cer. 82 pF 200 V 5%	MEPCO CV25NC820J	224194
C265	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C266	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C267	Capacitor, Var. 3.2-18 pF 250 V	Johansson 9313	281011
C268	Capacitor, Cer. 160 pF 200 V 5%	MEPCO CV35NC161J	224205
C269	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C270	Capacitor, Cer. 150 pF 150 V 20%	CV15GC151M	224189
C301	Capacitor, Cer. 3 pF 200 V 5%	MEPCO CV20COG330J	224203
C302	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C303 to C312	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C401	Capacitor, Cer. 100 nF 25 V -20/+80%	Erie 5815-000-104Z	224124
C402	Capacitor, Cer. 2 nF 500 V 20%	RMC SM	224213
C403	Capacitor, Cer. 2 nF 500 V 20%	RMC SM	224213
C404	Capacitor, Tant. 10 μF 25 V 20%	Sprague 196D106X0025KA1	283293
C405	Capacitor, Cer. 100 nF 25 V -20/+80%	Erie 5815-000-104Z	224124
C406	Capacitor, Tant. 10 μF 25 V 20%	Sprague 196D106X0025KA1	283293
C407	Capacitor, Cer. 12 pF 500 V 5%	Erie 301-000COGO829D	220124
C408	Capacitor, Cer. 100 nF 25 V -20/+80%	Erie 5815-000-104Z	224124
C409	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C410	Capacitor, Tant. 10 μF 25 V 20%	Sprague 196D106X0025KA1	283293
C411	Capacitor, Cer. 100 nF 25 V -20/+80%	Erie 5815-000-104Z	224124
C412	Capacitor, Cer. 8.2 pF ±0.25 pF 500 V	Erie 301-000COHO829C	220123

† For Option 102A-05 & 07
†† For Option 102A-06 & 07
☆ For Option 102A-08

* PINK SHEET

TABLE OF REPLACEABLE PARTS (Cont)

CAPACITORS

Ref.	Description	Manufacturer's Part No.	BEC Part No.
C413	Capacitor, Cer. 5 nF 500 V 20%	RMC SM	224213
C414	Capacitor, Tant. 10 μF 25 V 20%	Sprague 196D106X0025KA1	283293
C415	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C416	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C417	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C418	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C419	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C420	Capacitor, Cer. 75 pF 200 V 5%	MEPCO CV25NC750J	224197
C421	Capacitor, Cer. 100 pF 200 V 5%	MEPCO CV25NC101J	224202
C422	Capacitor, Cer. 100 pF 200 V 5%	MEPCO CV25NC101J	224202
C423	Capacitor, Cer. 160 pF 200 V 5%	MEPCO CV35NC161J	224205
C424	Capacitor, Cer. 100 pF 200 V 5%	MEPCO CV25NC101J	224202
C425	Capacitor, Cer. 160 pF 200 V 5%	MEPCO CV35NC161J	224205
C426	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C427	Capacitor, Cer. 75 pF 200 V 5%	MEPCO CV25NC750J	224197
C428	Capacitor, Cer. 100 pF 200 V 5%	MEPCO CV25NC101J	224202
C429	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C430	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C431	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C432	Capacitor, Cer. 5 nF 500 V 20%	RMC SM	224213
C433	Capacitor, Cer. 100 nF 25 V -20/+80%	Erie 5815-000-104Z	224124
C434	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C435	Capacitor, Cer. 56 pF 200 V 5%	MEPCO CV25NC560J	224193
C436	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C437	Capacitor, Var. 3.2-18 pF 250 V	Johansson 9313	281011
C438	Capacitor, Tant. 1 μF 35 V 20%	Sprague 196D105X9035HA1	283216
C439	Capacitor, Cer. 56 pF 200 V 5%	MEPCO CV25NC560J	224193
C440	Capacitor, Tant. 1 μF 35 V 20%	Sprague 196D105X9035HA1	283216
C441	Capacitor, Tant. 1 μF 35 V 20%	Sprague 196D105X9035HA1	283216
C442	Capacitor, Var. 3.2-18 pF 250 V	Johansson 9313	281011
C443	Capacitor, Cer. 8.2 pF ±0.25 pF 500 V	Erie 301-000COH0829C	220123
C444	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C445	Capacitor, Tant. 1 μF 35 V 20%	Sprague 196D105X9035HA1	283216
C446	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C447	Capacitor, Cer. 100 nF 25 V -20/+80%	Erie 5815-000-104Z	224124
C448	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C449	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C450	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C451	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C452	Capacitor, Cer. 5 nF 500 V 20%	RMC SM	224213
C453	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C454	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
* C455	Capacitor, Cer. 220 pF 20% 500 V	RMC JG	224212
C501	Capacitor, Tant. 10 μF 15 VNP -15/+75%	Mallory CL23BE100UNE	283294
C502	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X002MA3	283292
C503	Capacitor, Cer. 82 pF 200 V 5%	MEPCO CV25CN820J	224194
~~C504~~	~~Capacitor, Mica 100 pF 500 V 5%~~	~~ARCO DM15E101J~~	~~200001~~
C505	Capacitor, Tant. 10 μF 15 VNP -15/+75%	Mallory CL23BE100UNE	283294
C506	Capacitor, Tant. 22 μF 25 V 10%	Sprague 196D226X9025LA3	283308
C507	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C508	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C509	Capacitor, Tant 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C510	Capacitor, Tant. 10 μF 15 VNP -15/+75%	Mallory CL23BE100UNE	283294
C511	Capacitor, PE 100 nF 250 V 20%	MEPCO C280AE/P100K	234080
C512	Capacitor, PE 100 nF 250 V 20%	MEPCO C280AE/P100K	234080
C513	Capacitor, Var. 3.2-18 pF 250 V	Johansson 9313	281011
C514	Capacitor, Cer. 20 pF 500 V 5%	Erie 9313	220114
C515	Capacitor, PE 100 nF 250 V 20%	MEPCO C280AE/P100K	234080
C516	Capacitor, Tant. 10 μF 25 V 20%	Sprague 196D106X0025KA1	283293
C517	Capacitor, Mica 680 pF 500 V 10%	G.I. RDM19FD681 K03	200520
C518	Capacitor, PE 100 nF 250 V 20%	MEPCO C280AE/P100K	234080
C601	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C602	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C603	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C604	Capacitor, Cer. 1 nF 500 V GMC	Erie 831 ZU0102P	224114
C605	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C606	Capacitor, Cer. 5 nF 500 V 20%	RMC SM	224213
C607	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C608	Capacitor, Cer. 150 pF 150 V 20%	MEPCO CV15GC151M	224189
C609	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C610	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C611	Capacitor, Cer. 100 nF 25 V -20/+80%	Erie 5815-000-104Z	224124
C612	Capacitor, Cer. 10 nF 100 V 20%	Vitramon VJ1210X103MF	224210
C613	Capacitor, Cer. 470 pF 100 V 10%	Vitramon VJ0907A471KF	224216
C614	Capacitor, Cer. 10 nF 100 V 20%	Vitramon VJ1210X103 F	224210
C615	Capacitor, Cer. 10 nF 100 V 20%	Vitramon VJ1210X103 F	224210
C616	Capacitor, Cer. 10 nF 100 V 20%	Vitramon VJ1210X103 F	224210
C617	Capacitor, Cer. 10 nF 100 V 20%	Vitramon VJ1210X103 F	224210
C618	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C619	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C620	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C621	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C622	Capacitor, Elec. 25 μF 25 V	Sprague TE-1207	283172
C623	Capacitor, Cer. 3 pF ±0.25 pF 500 V	Erie 301-000-COJO 309C	220122
C624	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C625	Capacitor, Cer. 100 pF 600 V 5%	CRL DTZ-100	224215
C626	Capacitor, Elec. 25 μF 25 V	Sprague TE-1504	283172
C627	Capacitor, Cer. 33 pF 200 V 5%	MEPCO CV20COG330J	224203
C628	Capacitor, Cer. 470 pF 100 V 10%	Vitramon VJ0907A471KF	224216
C629	Capacitor, Mic. 2 nF 500 V 2%	G.I. RDM19FD202G03	200519
C630	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
*C631	Capacitor, Cer. 5 pF ±0.25 pF 500 V	Erie 301-000 COHO 509C	220120
*C632	Capacitor, Cer. 130 pF 200 V 5%	MEPCO CV35COG131J	224226
C633	Not Used		
*C634	Capacitor, Cer. 27 pF 200 V 5%	MEPCO CV15NC270J	224196
C635	Capacitor, Cer. 3 pF ±0.25 pF 500 V	Erie 301-000-COHO309C	220122
C636	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 ZU0102P	224114
C637	Capacitor, Cer. 1 nF 500 V GMV	Erie 831ZU0102P	224114
C701	Capacitor, Tant. 10 μF 25 V 20%	Sprague 196D106X0025KA1	283293
C801	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C802	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C803	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C804	Capacitor, PE 100 nF 250 V 20%	MEPCO C280AE/P100K	234080
C805	Capacitor, PE 100 nF 250 V 20%	MEPCO C280AE/P100K	234080
C806	Capacitor, PE 100 nF 250 V 20%	MEPCO C280AE/P100K	234080
C807	Capacitor, Elec. 1500-1500 μF 25 V	Mallory PWP201.3A	283296
C808	Capacitor, Elec. 1250 μF 50 V	Mallory PWP067A	283295
C809	Capacitor, Elec. 1250 μF 50 V	Mallory PWP067A	283295
C810	Capacitor, PE 22 nF 630 V 10%	Amperex C280MAG/A22K	234103
C811	Capacitor, PE 22 nF 630 V 10%	Amperex C280MAG/A22K	234103
C812	Capacitor, PE 22 nF 630 V 10%	Amperex C280MAG/A22K	234103
C901	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C902	Capacitor, Mica 10 nF 500 V 2%	G.I. RDM30FD103G03	203018
C903	Capacitor, Tant. 33 μF 15 V 20%	Sprague 196D336X0015FB	283206
C904	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C905	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C906	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C1001	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C1002	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C1003	Capacitor, Tant. 100 μF 20 V 20%	Sprague 196D107X0020MA3	283292
C1004	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C1005	Capacitor, Cer. 1 nF 500 V GMV	Erie 831 Z5U0102P	224114
C1006	Capacitor, Cer. 220 pF 500 V 20%	RMC JG	224212
C1007	Capacitor, Cer. 220 pF 20% 500 V	RMC JG	224212
C1008	Capacitor, Cer. 220 pF 20% 500 V	RMC JG	224212

RESISTORS

R1	Resistor, MF 1.15 kΩ 1% 3/8W		326256
R2	Resistor, MF 1.15 kΩ 1% 3/8W		326256
~~R3~~	~~Resistor, MF~~ 750 Ω 1% 3/8W		326091
~~R4~~	~~Resistor, MF~~ 750 Ω 1% 3/8W		326091
R5	Resistor, MF 1.15 kΩ 1% 3/8W		326256
R6	Resistor, MF 1.15 kΩ 1% 3/8W		326256
R7	Resistor, Comp. 5.1 kΩ 5% 1/2W		301104
R8	Resistor, MF 845 Ω 1% 3/8W		326099
R9	Resistor, MF 3.01 kΩ 1% 3/8W		340297

*For 102A-03 Option only

* PINK SHEET

TABLE OF REPLACEABLE PARTS (Cont)

Ref.	Description	Manufacturer's Part No.	BEC Part No.
	RESISTORS		
R10	Resistor, MF 845 Ω 1% 3/8W		326099
R11	Resistor, MF 604 Ω 1% 3/8W		340213
R12	Resistor, MF 32.4 kΩ 1% 3/8W		340420
R13	Resistor, Comp. 5.1 kΩ 5% 1/2W		301104
R14	Resistor, Var. 600 Ω Bridged-T Attenuator	A-B 70C1 N200P601P	311310
R15	Resistor, MF 604 Ω 1% 3/8W		340213
R16	Resistor, Comp. 100 Ω 5% 1/4W		300058
R17	Resistor, Var. 500 Ω 10% 2W	A-B JA1H200P501UA	311309
R18	Resistor, Comp. 100 Ω 5% 1/4W		300058
R19	Resistor, Comp. 100 Ω 5% 1/4W		300058
R20	Resistor, MF 127 kΩ 1% 3/8W		340491
R21	Resistor, MF 127 kΩ 1% 3/8W		340491
R22	Resistor, MF 51.1 kΩ 1% 3/8W		340443
R23	Resistor, MF 51.1 kΩ 1% 3/8W		340443
R24	Resistor, MF 16.9 kΩ 1% 3/8W		340386
R25	Resistor, MF 16.9 kΩ 1% 3/8W		340386
R26	Resistor, MF 5.11 kΩ 1% 3/8W		340324
R27	Resistor, MF 5.11 kΩ 1% 3/8W		340324
*R28	Resistor, MF 2.74 kΩ 1% 3/8W		340292
*R29	Resistor, MF 2.74 kΩ 1% 3/8W		340292
R30	Resistor, MF 1.82 kΩ 1% 3/8W		340263
R31	Resistor, MF 453 Ω 1% 3/8W		340198
R32	Resistor, MF 1.82 kΩ 1% 3/8W		340263
R33	Resistor, MF 1.0 kΩ 1% 3/8W		340239
R34	Resistor, MF 1.13 kΩ 1% 3/8W		340246
R35	Resistor, MF 1.0 kΩ 1% 3/8W		340239
R36	Resistor, MF 768 Ω 1% 3/8W		340226
R37	Resistor, MF 768 Ω 1% 3/8W		340226
R38	Resistor, MF 2.37 kΩ 1% 3/8W		340284
R39	Resistor, Var. 50 Ω 10% 1W	A-B 70A1N200P500U	311329
R40	Resistor, Comp. 3 kΩ 5% 1/2W		301098
R41	Resistor, Var. 2 kΩ 10% 2W	A-B JA1N200P202UA	311317
*R42	Resistor, Comp. 680 Ω 5% 1/2W		301083
†R45	Resistor, Comp. 10 kΩ 5% 1/4W		300106
†R46	Resistor, Comp. 10 kΩ 5% 1/4W		300106
†R47	Resistor, Comp. 10 kΩ 5% 1/4W		300106
†R51	Resistor, Comp. 10 kΩ 5% 1/4W		300106
††R52	Resistor, Comp. 10 kΩ 5% 1/4W		300106
††R53	Resistor, Comp. 10 kΩ 5% 1/4W		300106
☆R56	Resistor, MF 28.7 kΩ 1% 3/8W		340414
☆R57	Resistor, MF 10.0 kΩ 1% 3/8W		326376
☆R58	Resistor, Comp. 1.5 kΩ 5% 1/2W		301091
☆R59	Resistor, Comp. 680 Ω 5% 1/2W		301083
☆R60	Resistor, Comp. 510 Ω 5% 1/2W		301080
R101	Resistor, MF 51.1 kΩ 1% 3/8W		340443
R102	Resistor, MF 243 Ω 1% 3/8W		340166
R103	Resistor, Comp. 150 Ω 5% 1/4W		300062
R104	Resistor, Comp. 150 Ω 5% 1/4W		300062
R105	Resistor, Comp. 62 Ω 5% 1/4W		300053
R106	Not Used		
R107	Not Used		
R108	Resistor, MF 1.0 kΩ 1% 3/8W		340239
R109	Resistor, MF 604 Ω 1% 3/8W		340213
R201	Resistor, Comp. 3 kΩ 5% 1/2W		301098
R202	Resistor, Comp. 2 kΩ 5% 1/2W		301094
R203	Resistor, Comp. 620 Ω 5% 1/2W		301082
R204	Resistor, Comp. 150 Ω 5% 1/2W		301067
R205	Resistor, Comp. 220 Ω 5% 1/2W		301071
R206	Resistor, Comp. 5.6 Ω 5% 1/2W		301506
R207	Resistor, Comp. 150 Ω 5% 1/2W		301067
R208	Resistor, Comp. 270 Ω 5% 1/2W		301073
R209	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R210	Resistor, Comp. 47 Ω 5% 1/2W		301055
R211	Resistor, Comp. 47 Ω 5% 1/2W		301055

* For Option 102A-03
† For Option 102A-05 & 07
†† For Option 102A-06 & 07
☆ For Option 102A-08

Ref.	Description	Manufacturer's Part No.	BEC Part No.
R212	Resistor, Comp. 470 Ω 5% 1/2W		301079
R213	Resistor, Comp. 47 Ω 5% 1/4W		300050
R214	Resistor, Comp. 5.6 Ω 5% 1/2W		301506
R215	Resistor, Comp. 100 Ω 5% 1/4W		300058
R216	Resistor, Comp. 680 Ω 5% 1/4W		300078
R217	Resistor, Comp. 680 Ω 5% 1/2W		301083
R218	Resistor, Comp. 150 Ω 5% 1/2W		301067
R219	Resistor, Comp. 5.6 kΩ 5% 1/2W		301105
R220	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R221	Resistor, Comp. 680 Ω 5% 1/4W		300078
R222	Resistor, Comp. 75 Ω 5% 1/4W		300055
R223	Resistor, Comp. 75 Ω 5% 1/4W		300055
R224	Resistor, Comp. 330 Ω 5% 1/4W		300070
R225	Resistor, Comp. 680 Ω 5% 1/4W		300078
R226	Resistor, Comp. 680 Ω 5% 1/4W		300078
R227	Resistor, Comp. 680 Ω 5% 1/4W		300078
R228	Not Used		
R229	Resistor, Comp. 56 Ω 5% 1/4W		300052
R230	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R231	Resistor, Comp. 680 Ω 5% 1/4W		300078
R232	Resistor, Comp. 680 Ω 5% 1/4W		300078
R233	Resistor, Comp. 680 Ω 5% 1/4W		300078
R234	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R235	Resistor, Comp. 680 Ω 5% 1/4W		300078
R236	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R237	Resistor, Comp. 100 Ω 5% 1/4W		300058
R238	Resistor, Comp. 680 Ω 5% 1/4W		300078
R239	Resistor, Comp. 680 Ω 5% 1/4W		300078
R240	Resistor, Comp. 680 Ω 5% 1/4W		300078
R241	Resistor, Comp. 680 Ω 5% 1/4W		300078
R242	Resistor, Comp. 680 Ω 5% 1/4W		300078
R243	Resistor, Comp. 680 Ω 5% 1/4W		300078
R244	Resistor, Comp. 150 Ω 5% 1/2W		301067
R245	Resistor, Comp. 2 kΩ 5% 1/2W		301094
R246	Resistor, Comp. 3 kΩ 5% 1/2W		301098
R247	Resistor, Comp. 15 Ω 5% 1/2W		301043
R248	Resistor, Comp. 150 Ω 5% 1/2W		301067
R249	Resistor, Comp. 56 Ω 5% 1/4W		300052
R250	Resistor, Comp. 2 kΩ 5% 1/2W		301094
R251	Resistor, Comp. 3 kΩ 5% 1/2W		301098
R252	Resistor, Comp. 150 Ω 5% 1/2W		301067
R253	Resistor, Comp. 18 Ω 5% 1/2W		301045
R254	Resistor, Comp. 150 Ω 5% 1/2W		301067
R301	Resistor, Comp. 680 Ω 5% 1/4W		300078
R302	Resistor, Comp. 680 Ω 5% 1/4W		300078
R303	Resistor, Comp. 680 Ω 5% 1/4W		300078
R304	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R305	Resistor, Comp. 680 Ω 5% 1/4W		300078
R306	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R307	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R308	Resistor, Comp. 680 Ω 5% 1/4W		300078
R309	Resistor, Comp. 680 Ω 5% 1/4W		300078
R310	Resistor, Comp. 680 Ω 5% 1/4W		300078
R311	Resistor, Comp. 680 Ω 5% 1/4W		300078
R401	Resistor, Comp. 1 MΩ 5% 1/2W		301159
R402	Resistor, Comp. 680 Ω 5% 1/2W		301083
R403	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R404	Resistor, Var. 500 Ω 10% 1/2W	Beckman Model 72P	311305
R405	Resistor, Comp. 270 Ω 5% 1.2W		301073
R406	Resistor, Comp. 220 Ω 5% 1/2W		301071
R407	Resistor, Comp. 68 Ω 5% 1/2W		301059
R408	Resistor, Comp. 100 Ω 5% 1/4W		300058
R409	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R410	Resistor, Comp. 120 Ω 5% 1/2W		301065
R411	Resistor, Comp. 100 Ω 5% 1/4W		300058
R412	Resistor, Comp. 1 kΩ 5% 1/2W		301087
*R414	Resistor, Comp. 390 Ω 5% 1/2W		301077
R415	Resistor, Comp. 56 Ω 5% 1/2W		301057
R416	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R417	Resistor, Comp. 220 Ω 5% 1/2W		301071
R418	Resistor, Comp. 620 Ω 5% 1/2W		301082
R419	Resistor, Comp. 150 Ω 5% 1/2W		301067
R420	Resistor, Comp. 47 Ω 5% 1/2W		301055

* PINK SHEET

TABLE OF REPLACEABLE PARTS (Cont)

RESISTORS

Ref.	Description	Manufacturer's Part No.	BEC Part No.
R421	Resistor, Comp. 47Ω 5% 1/2W		301055
R422	Resistor, Comp. 680 Ω 5% 1/2W		301083
R423	Resistor, Comp. 47Ω 5% 1/2W		301055
R424	Resistor, Comp. 27Ω 5% 1/2W		301049
R425	Resistor, Comp. 15Ω 5% 1/2W		301043
R426	Resistor, Comp. 15Ω 5% 1/2W		301043
R427	Resistor, Comp. 470 Ω 5% 1/2W		301079
R428	Resistor, Comp. 82Ω 5% 1/2W		301061
R429	Resistor, Comp. 470Ω 5% 1/2W		301079
R430	Resistor, Comp. 470Ω 5% 1/2W		301079
R431	Resistor, Comp. 470Ω 5% 1/2W		301079
R432	Resistor, Comp. 560Ω 5% 1/2W		301081
R433	Resistor, Comp. 170Ω 5% 1/2W		301073
R434	Resistor, Comp. 270Ω 5% 1/2W		301073
R435	Resistor, Comp. 18Ω 5% 1/2W		301045
R436	Resistor, Comp. 680Ω 5% 1/2W		301083
R437	Resistor, Comp. 68Ω 5% 1/2W		301059
R438	Resistor, Comp. 36Ω 5% 1/2W		301052
R439	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R440	Resistor, Comp. 56Ω 5% 1/2W		301057
R441	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R442	Resistor, Comp. 3.3 kΩ 5% 1/2W		301099
R443	Resistor, Comp. 56Ω 5% 1/2W		301057
R444	Resistor, Comp. 100Ω 5% 1/2W		301063
R445	Resistor, Comp. 12 kΩ 5% 1/2W		301113
R446	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R447	Resistor, Comp. 15Ω 5% 1/2W		301043
R448	Resistor, Comp. 68Ω 5% 1/2W		301059
R449	Resistor, Comp. 12 kΩ 5% 1/2W		301113
R450	Resistor, Comp. 330Ω 5% 1/2W		301075
R451	Resistor, Comp. 100Ω 5% 1/2W		301063
R452	Resistor, Comp 56Ω 5% 1/2W		301057
R453	Resistor, Comp. 12 kΩ 5% 1/2W		301113
R454	Resistor, Comp. 330Ω 5% 1/2W		301075
R455	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R456	Resistor, Comp. 12 kΩ 5% 1/2W		301113
R457	Resistor, Comp. 3.3 kΩ 5% 1/2W		301099
R458	Resistor, Comp. 62Ω 5% 1/2W		301058
R459	Resistor, Comp. 56Ω 5% 1/2W		301057
R460	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R461	Resistor, Comp. 7.5 kΩ 5% 1/2W		301108
R462	Resistor, Comp. 750 Ω 5% 1/2W		301084
R463	Resistor, Comp. 18Ω 5% 1/2W		301045
R464	Resistor, Comp. 1.2 kΩ 5% 1/2W		301089
R465	Resistor, Comp. 68Ω 5% 1/2W		301059
R466	Resistor, Comp. 10 kΩ 5% 1/2W		301111
R501	Resistor, MF 51.1 kΩ 1% 3/8W		340443
R502	Resistor, Var. 5 kΩ 10% 1/2W	Beckman Model 72P	311308
R503	Resistor, MF 5.11 kΩ 1% 3/8W		340324
R504	Resistor, MF 5.11 kΩ 1% 3/8W		340324
R505	Resistor, Var. 500Ω 10% 1/2W	Beckman Model 72P	311305
R506	Resistor, Comp. 2 kΩ 5% 1/2W		301094
R507	Resistor, Comp. 3.9 MΩ 5% 1/2W		301173
R508	Resistor, Comp. 180Ω 5% 1/2W		301069
R509	Resistor, Comp. 2.2 kΩ 5% 1/2W		301095
R510	Resistor, Comp. 10 kΩ 5% 1/2W		301111
R511	Resistor, MF 82.5Ω 1% 3/8W		340110
R512	Resistor, Comp. 1.8 kΩ 5% 1/2W		301093
R513	Resistor, Var. 1 kΩ 10% 1/2W	Beckman Model 72P	311316
R514	Resistor, Comp. 560Ω 5% 1/2W		301081
R515	Resistor, Comp. 3 kΩ 5% 1/2W		301098
R516	Resistor, Comp. 510Ω 5% 1/2W		301080
R517	Resistor, Comp. 510Ω 5% 1/2W		301080
R518	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R519	Resistor, Comp. 3 kΩ 5% 1/2W		301098
R520	Resistor, Comp. 10 kΩ 5% 1/2W		301111
R521	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R522	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R523	Resistor, Comp. 390Ω 5% 1/2W		301077
R524	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R525	Resistor, Comp. 220Ω 5% 1/2W		301071
R526	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R527	Resistor, Comp. 220Ω 5% 1/2W		301071
R601	Resistor, Comp. 680Ω 5% 1/4W		300078
R602	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R603	Resistor, Comp. 680Ω 5% 1/4W		300078
R604	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R605	Resistor, Comp. 680Ω 5% 1/4W		300078
R606	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R607	Resistor, Comp. 680Ω 5% 1/4W		300078
R608	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R609	Resistor, Comp. 680Ω 5% 1/4W		300078
R610	Resistor, Comp. 56 kΩ 5% 1/4W		300124
R611	Resistor, Comp. 680Ω 5% 1/4W		300078
R612	Resistor, Comp. 10 kΩ 5% 1/2W		301111
R613	Resistor, Comp. 1.5 kΩ 5% 1/2W		301091
R614	Resistor, Comp. 240Ω 5% 1/4W		300067
R615	Resistor, Comp 240Ω 5% 1/4W		300067
R616	Resistor, Comp. 330Ω 5% 1/2W		301075
R617	Resistor, Comp. 270Ω 5% 1/4W		300068
R618	Resistor, Comp. 1 kΩ 5% 1/2W		301087
*R619	Resistor, Comp. 30 kΩ 5% 1/4W		300117
R620	Resistor, Comp. 75 kΩ 5% 1/2W		301132
R621	Resistor, Comp. 1.5 kΩ 5% 1/2W		301091
R622	Resistor, Comp. 10 kΩ 5% 1/2W		301111
R623	Resistor, MF 39.2 kΩ 1% 3/8W		340430
R624	Resistor, Comp. 10 kΩ 5% 1/2W		301111
R625	Resistor, Comp. 1 mΩ 5% 1/2W		301159
R626	Resistor, Comp. 680Ω 5% 1/4W		300078
R627	Resistor, Comp. 1.5 kΩ 5% 1/2W		301091
R628	Resistor, Comp. 10 kΩ 5% 1/2W		301111
*R629	Resistor, Comp. 120 kΩ 5% 1/4W		300132
R630	Resistor, MF 7.8 kΩ 1% 3/8W		340347
R631	Resistor, CF 50Ω 1% 1/10W		335800
R701	Resistor, Comp. 1 kΩ 5% 1/2W		301087
R801	Resistor, Comp. 82Ω 5% 1W		302075
R802	Resistor, MF 150Ω 1% 3/8W		340141
R803	Resistor, Var. 200Ω 10% 1/2W	Beckman Model 72P	311304
R804	Resistor, MF 1.40 kΩ 1% 3/8W		326259
R805	Resistor, MF 1.62 kΩ 1% 3/8W		340267
R806	Resistor, Var. 200Ω 10% 1/2W	Beckman Model 72P	311304
R807	Resistor, MF 604Ω 1% 3/8W		340213
R808	Resistor, MF 1.62 kΩ 1% 3/8W		340267
R809	Resistor, Var. 200Ω 10% 1/2W	Beckman Model 72P	311304
R810	Resistor, MF 604Ω 1% 3/8W		340213
R811	Resistor, WW 0.6Ω 5% 3W		310006
R812	Resistor, WW 1Ω 5% 3W		310007
R813	Resistor, WW 1Ω 5% 3W		310007
R814	Resistor, Comp. 680 Ω 5% 1/2W		301083
R815	Resistor, Comp. 680 Ω 5% 1/2W		301083
R816	Resistor, Comp. 680Ω 5% 1/2W		301083
R817	Resistor, Comp. 10Ω 5% 1/2W		301039
R818	Resistor, Comp. 10Ω 5% 1/2W		301039
R819	Resistor, Comp. 10Ω 5% 1/2W		301039
R820	Resistor, Comp. 1 kΩ 5% 1W		302100
R821	Resistor, Comp. 3.3 kΩ 5% 1W		302112
R822	Resistor, Comp. 3.3 kΩ 5% 1W		302112
R823	Resistor, Comp. 47Ω 5% 1/2W		301055
R901	Resistor, MF 5.11 kΩ 1% 3/8W		340324
R902	Resistor, MF 2.37 kΩ 1% 3/8W		340284
R903	Resistor, MF 9.09 kΩ 1% 3/8W		340354
R904	Resistor, Var. 5 kΩ 10% 1/2W	Beckman Model 72XW	311307
R905	Resistor, Var. 5 kΩ 10% 1/2W	Beckman Model 72XW	311307
R906	Resistor, MF 10.0 kΩ 1% 3/8W		326376
R907	Resistor, Var. 5 kΩ 10% 1/2W	Beckman Model 72XW	311307
R908	Resistor, MF 5.11 kΩ 1% 3/8W		340324
*R909	Resistor, MF 5.11 kΩ 1% 3/8W		340324
*R910	Resistor, MF 7.87 kΩ 1% 3/8W		340347
*R911	Resistor, MF 453Ω 1% 3/8W		340198
*R912	Resistor, MF 1.00 kΩ 1% 3/8W		340239

*For 102A-03 Option only

* PINK SHEET

TABLE OF REPLACEABLE PARTS (Cont)

Ref.	Description		Manufacturer's Part No.	BEC Part No.
RESISTORS				
* R913	Resistor, MF	1.62 kΩ 1% 3/8W		340267
R914	Resistor, MF	7.50 kΩ 1% 3/8W		326305
R915	Resistor, Var.	100Ω 10% 1/2W	Beckman Model 72XW	311306
R916	Resistor, MF	100Ω 1% 3/8W		326031
R917	Resistor, MF	1.10 kΩ 1% 3/8W		340244
*R918	Resistor, MF	35.7Ω 1% 3/8W		340067
*R918	Resistor, MF	30.1Ω 1% 3/8W		340058
*R918	Resistor, MF	31.6Ω 1% 3/8W		340061
*R918	Resistor, MF	33.2Ω 1% 3/8W		340063
R1001	Resistor, MF	49.9Ω 1% 3/8W		340084
OTHER COMPONENTS				
L101	Coil, Var.		Mallory 516X235	400253
L102	Choke, RF	1 μH 10%	Jeffers 4425-6K	400248
L103	Choke, RF	1 μH 10%	Jeffers 4425-6K	400248
L104	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L105	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L106	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L201	Choke, RF	150 nH 20%	Jeffers 4415-1M	400246
L202	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L203	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L204	Choke, RF	100 nH 10%	Caddell-Burns 660-1	400242
L205	Coil	70 nH	Boonton Electronics	400260
L206	Choke, RF	100 nH 10%	Caddell-Burns 660-1	400242
L207	Coil, RF	70 nH	Boonton Electronics	400260
L208	Choke, RF	100 nH 10%	Caddell-Burns 660-1	400242
L209	Coil, RF	70 nH	Boonton Electronics	400260
L210	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L211	Choke, RF	470 nH 20%	Jeffers 4425-2K	400252
L212	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L213	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L214	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L215	Choke, RF	300 nH 10%	Caddell-Burns 660-3	400244
L216	Choke, RF	100 nH 10%	Caddell-Burns 660-1	400242
L217	Choke, RF	150 nH 20%	Jeffers 4415-1M	400246
L218	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L219	Coil, RF	36 nH	Boonton Electronics	400259
L220	Choke, RF	150 nH 20%	Jeffers 4415-1M	400246
L221	Choke, RF	470 nH 20%	Jeffers 4425-2K	400252
L222	Choke, RF	150 nH 20%	Jeffers 4415-1M	400246
L223	Choke, RF	470 nH 20%	Jeffers 4425-2K	400252
L224	Choke, RF	1 μH 10%	Jeffers 4425-6K	400248
L401	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L402	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L403	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L404	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L405	Choke, RF	150 nH 20%	Jeffers 4415-1M	400246
L406	Choke, RF	200 nH 10%	Caddell-Burns 660-2	400243
L407	Choke, RF	150 nH 20%	Jeffers 4415-1M	400246
L408	Choke, RF	220 nH 20%	Jeffers 4415-2M	400247
L409	Choke, RF	150 nH 20%	Jeffers 4415-1M	400246
L410	Choke, RF	200 nH 10%	Caddell-Burns 660-2	400243
L411	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L412	Choke, RF	300 nH 10%	Caddell-Burns 660-3	400244
L413	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L414	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L415	Choke, RF	680 nH 10%	Jeffers 4425-4K	400251
L416	Choke, RF	270 nH 10%	Jeffers 4416-6K	400250
L417	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L418	Choke, RF	2.7 μH 10%	Jeffers 4425-11K	400249
L501	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L601	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
L602	Choke, RF	10 μH 10%	Jeffers 4445-2K	400245
*L603	Choke, RF	20 μH 5%	Jeffers 4445-6J	400258

Ref.	Description		Manufacturer's Part No.	BEC Part No.
†A1	Op. Amp.	LM318H		535010
††A2	Op. Amp.	LM318H		535010
A501	Op. Amp.	LM318H	National Semi.	535010
A502	Op. Amp.	LM311	National Semi.	535006
A503	Op. Amp.	LM310	National Semi.	535005
A601	Op. Amp	RF Output	Special	421025
A602	Op. Amp	MC1709G	Motorola	421024
*A603	Op. Amp	LM318H	National Semi.	535010
CR101	Diode, Signal	1N5470A	Motorola only	530753
CR102	Diode, Signal	1N5470A	Motorola only	530753
CR201	Diode, Zener	1N752A 5.6 V	Centralab	530134
CR202 to CR207	Diode	HP5082-3080	H.P.	530137
CR208	Diode	Quad, matched	H.P.	530903
CR209 to CR216	Diode	HP5082-3080	H.P.	530137
CR301 to CR306	Diode	HP5082-3080	H.P.	530137
CR401	Diode, Sil.	FD-777	Fairchild	530127
CR402	Diode, Sil.	FD-777	Fairchild	530127
CR403	Diode, Zener	1N752A 5.6 V	Centralab	530134
CR404 to CR407	Diode, Diode	5082-3080 5082-3080	H.P. H.P.	530137 530137
CR408	Diode	1N4148	T.I.	530058
CR601 to CR609	Diode	5082-3080	H.P.	530137
CR610	Diode, Zener	1N5239B 9.1 V	Motorola	530130
CR611	Diode	5082-2810	H.P.	530135
CR701	Diode	FD-777	Fairchild	530127
CR801	Diode	1N4148	T.I.	530058
CR802	Diode	1N4148	T.I.	530058
CR803	Diode	1N4148	T.I.	530058
CR804	Diode	1N4148	T.I.	530058
CR805	Diode, Bridge	VS-248 2.0 Amp	VARO	532014
CR806	Diode, Bridge	VE-68 1.0 Amp	VARO	532011
CR807	Diode, Bridge	VE-68 1.0 Amp	VARO	532011
CR901	Diode, Zener	7.4 V	MOT 0.5M 7.4ZS1	530147
IC401	Integ. Circuit	SN74S112N	T.I.	534036
IC402	Integ. Circuit	SN74H102N	T.I.	523037
IC403	Integ. Circuit	SN74H102N	T.I.	523037
IC501	Int. Circuit	NAND Gate SN7400N	T.I.	534034
IC502	Int. Circuit	Decade Counter SN7490N	T.I.	534035
IC503	Int. Circuit	Counter SN7493N	T.I.	534033
IC504	Int. Circuit	Decade Counter SN7490N	T.I.	534035
IC505	Int. Circuit	Decade Counter SN7490N	T.I.	534035
IC506	Int. Circuit	Flip-Flop SN7472N	T.I.	534032
IC507	Int. Circuit	Decade Counter SN7490N	T.I.	534035
IC508	Int. Circuit	Decade Counter SN7490N	T.I.	534035
IC509	Int. Circuit	Driver SN75450N	T.I.	535009
IC510	Int. Circuit	Tri-State Buffer DM8094N	National Semi.	534060
IC701 to IC706	Int. Circuit	Decade Counter SN7490N	T.I.	534035

* For Option 102A-03
† For Option 102A-05 & 07
†† For Option 102A-06 & 07

* ERRATA - PINK SHEET

TABLE OF REPLACEABLE PARTS (Cont)

Ref.	Description		Manufacturer's Part No.	BEC Part No.
OTHER COMPONENTS				
IC801	Int. Circuit	Regulator MFC6030	Motorola	535007
IC802	Int. Circuit	Regulator MFC6030	Motorola	535007
IC803	Int. Circuit	Regulator MFC6030	Motorola	535007
☆Q1	Transistor	NPN 2N3904		528071
☆Q2	Transistor	NPN 2N3904		528071
Q101	FET	2N4416	Motorola only	528072
Q201	Transistor	PNP MPS3640	Motorola	528079
Q202	Transistor	NPN 2N5109	RCA only	528073
Q203	Transistor	NPN MPS6507	Motorola	528070
Q204	Transistor	NPN MPS6507	Motorola	528070
Q205	Transistor	PNP MPS3640	Motorola	528079
Q206	Transistor	NPN 2N5109	RCA only	528073
Q207	Transistor	NPN 2N5109	RCA only	528073
Q401	FET	2N4416	Motorola	528072
Q402	Transistor	PNP 2N3906	Motorola	528076
Q403	Transistor	NPN MPS6507	Motorola	528070
Q404	Transistor	NPN MPS6520	Motorola	528077
Q405	Transistor	PNP MPS3640	Motorola	528079
Q406	Transistor	PNP MPS3640	Motorola	528079
Q407	Transistor	NPN MPS6507	Motorola	528070
Q408	Transistor	NPN 2N5179	Motorola	528080
Q409	Transistor	NPN 2N5179	Motorola	528080
Q410 to Q414	Transistor	NPN 2N3904	Motorola	528071
Q501	Transistor	NPN 2N3904	Motorola	528071
Q502	Transistor	NPN 2N3904	Motorola	528071
Q801	Transistor	NPN 40250	RCA	528074
Q802	Transistor	NPN 40250	RCA	528074
Q803	Transistor	NPN 40250	RCA	528074
Q901	Transistor	PNP MPS-A66	Motorola	528048
AT1		VHF Step Attenuator	Boonton Electronics	562000
DS1	Lamp	28 V; Part of S6		
DS501	Lamp	No. 1869	Chicago	545123
DS701	Display, Num	5082-7300	H.P.	536801
to DS706	Display, Num.	5082-7300	H.P.	536801
FL101		RFI Filter Assembly (orn)	Boonton Electronics	102020-1
FL102		RFI Filter Assembly (orn)	Boonton Electronics	102020-1
FL103		RFI Filter Assembly (red)	Boonton Electronics	102019-1
FL1001		RFI Filter Assembly (orn)	Boonton Electronics	102020-1
to FL1005		RFI Filter Assembly (orn)	Boonton Electronics	102020-1
*FL1006		RFI Filter Assembly 4 (yel)	Boonton Electronics	102057-1
FL1007		RFI Filter Assembly (orn)	Boonton Electronics	102020-1
to FL1008		RFI Filter Assembly (orn)	Boonton Electronics	102020-1
FL1009		RFI Filter Assembly (brn)	Boonton Electronics	102018-1
FL1010		RFI Filter Assembly (orn)	Boonton Electronics	102020-1
FL1011		RFI Filter Assembly (orn)		102020-1
F1	Fuse	0.5 A 115 V Slo Blo	Buss	545504
F1	Fuse	0.25 A 230 V Slo Blo	Buss	545511
**F2	Fuse, RF	50FL8	Alan	545999
M1		Meter and Scale, Modulation	Ammon FM-2 modified	554272
M901		Meter and Scale, RF	Ammon FM-2 modified	554269
T1	Transformer	Power	VARO	446064
T201	Transformer	Toroidal, RF	Boonton Electronics	410064
to T206	Transformer	Toroidal, RF	Boonton Electronics	410064
T401	Transformer	Toroidal, RF	Boonton Electronics	410063
Z401	Mixer, Balanced	MCL SRA-1	MC Lab	423000
Y401	Crystal, Quartz	70 MHz	Valpey Fisher VM6	547026
Y501	Crystal, Quartz	1 MHz	Valpey Fisher VR6E	547025

* For Option 102A-03
** For Option 102A-04
☆ For Option 102A-08

SECTION VI

SCHEMATIC DIAGRAMS

E830594E

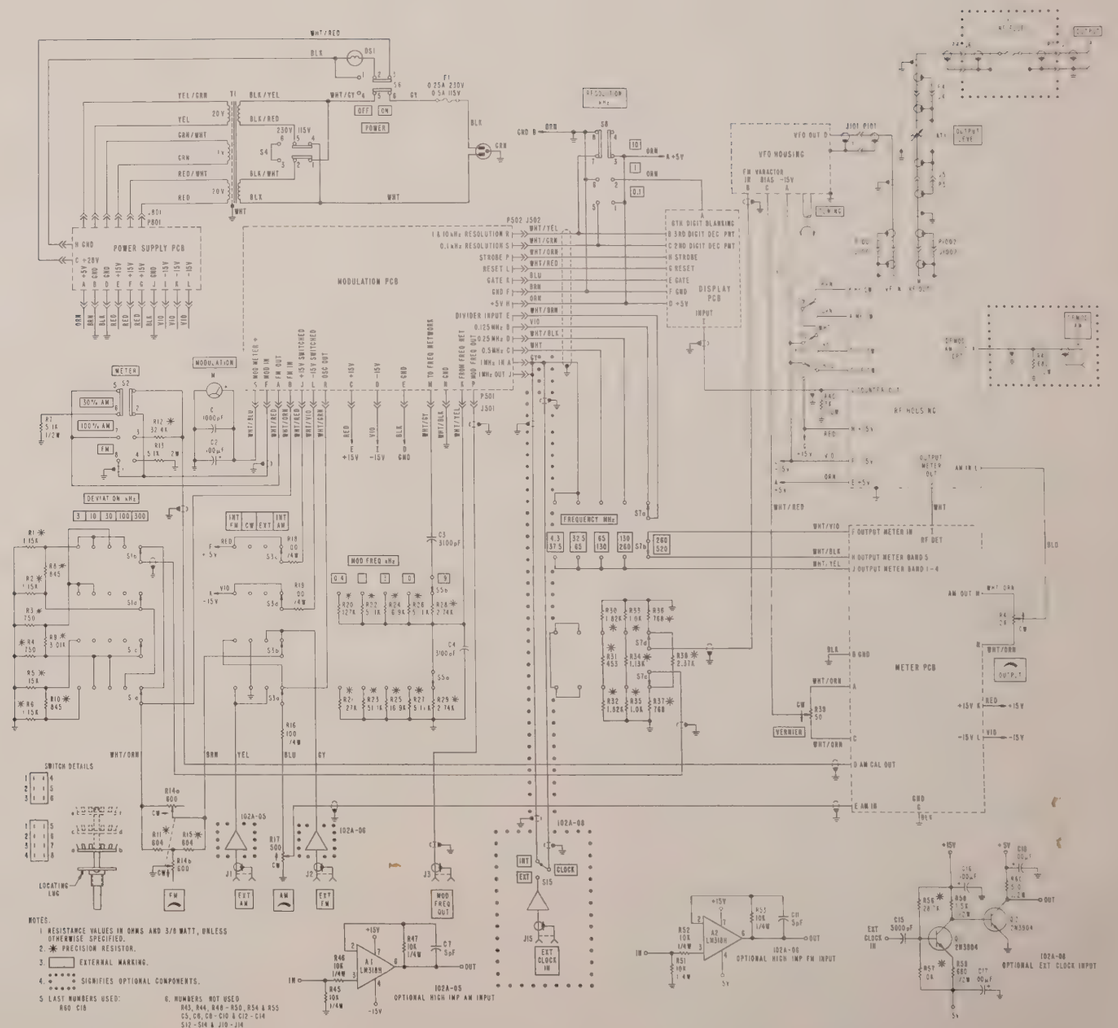
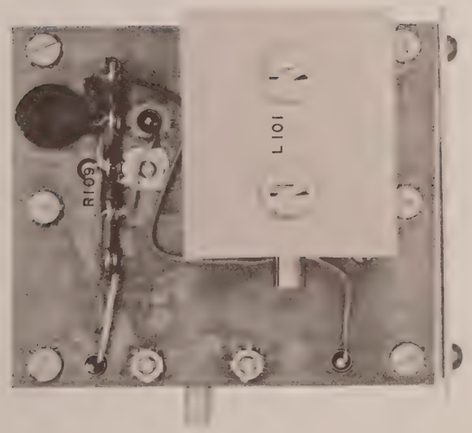
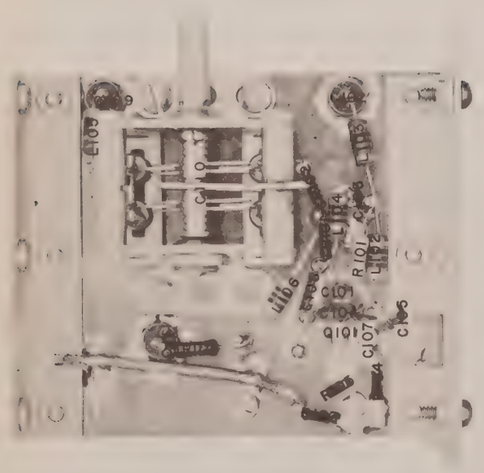
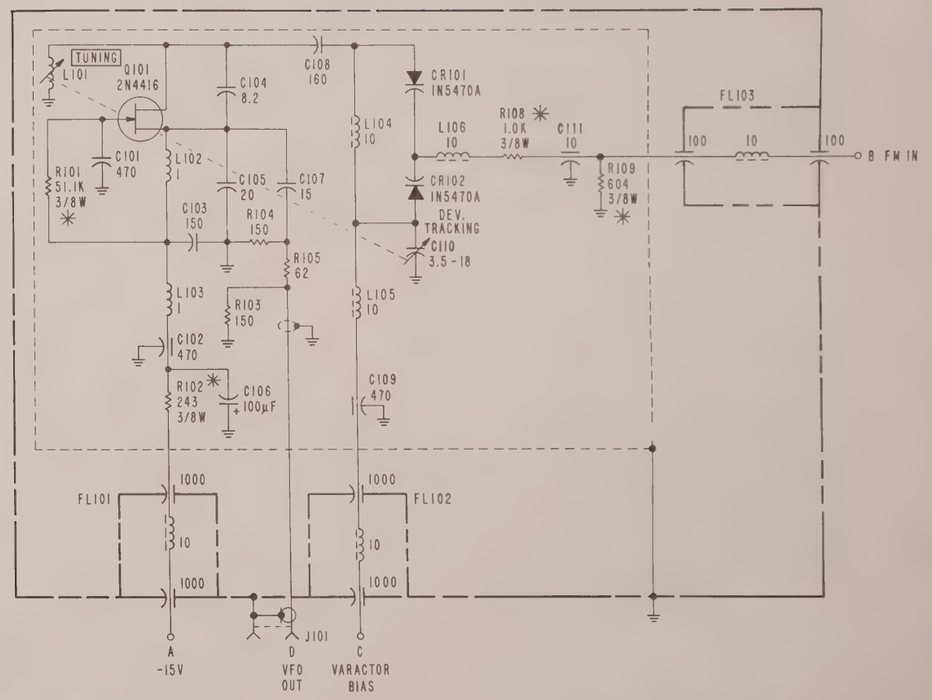


Figure 6-1 Main Frame, Schematic Diagram

C8305940







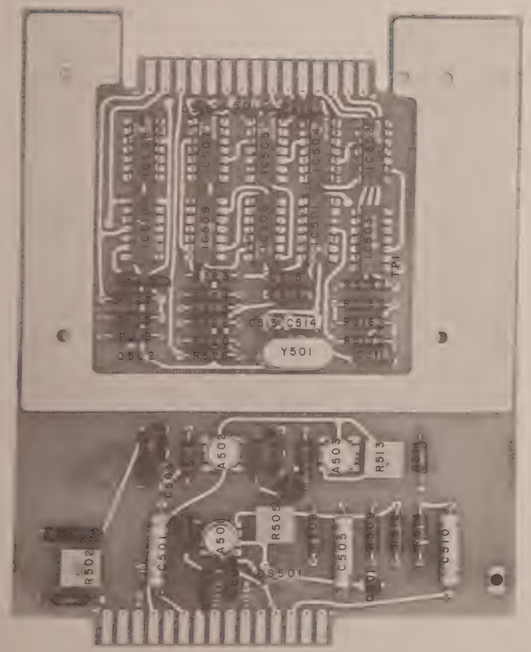
NOTES:

1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
3. INDUCTANCE VALUES IN µH UNLESS OTHERWISE SPECIFIED.
4. LAST NUMBERS USED: R109 C111 L104
5. ✳ PRECISION RESISTOR
6. NUMBERS NOT USED: R106 R107
7. ▭ EXTERNAL MARKING.

VFO HOUSING IDENTIFICATION

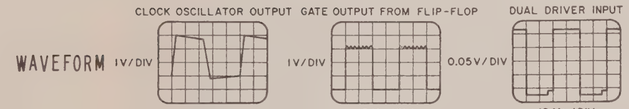
Figure 6-2 VFO Housing, Schematic Diagram

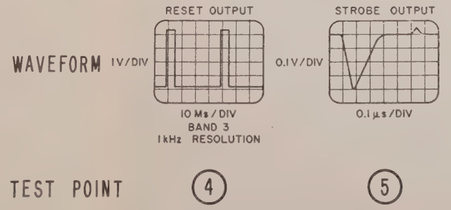
E83059-2



NOTES:

1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/2WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTOR 3/8 WATT.
4. ▭ EXTERNAL MARKINGS.
5. LAST NUMBERS USED:
   R527 C518





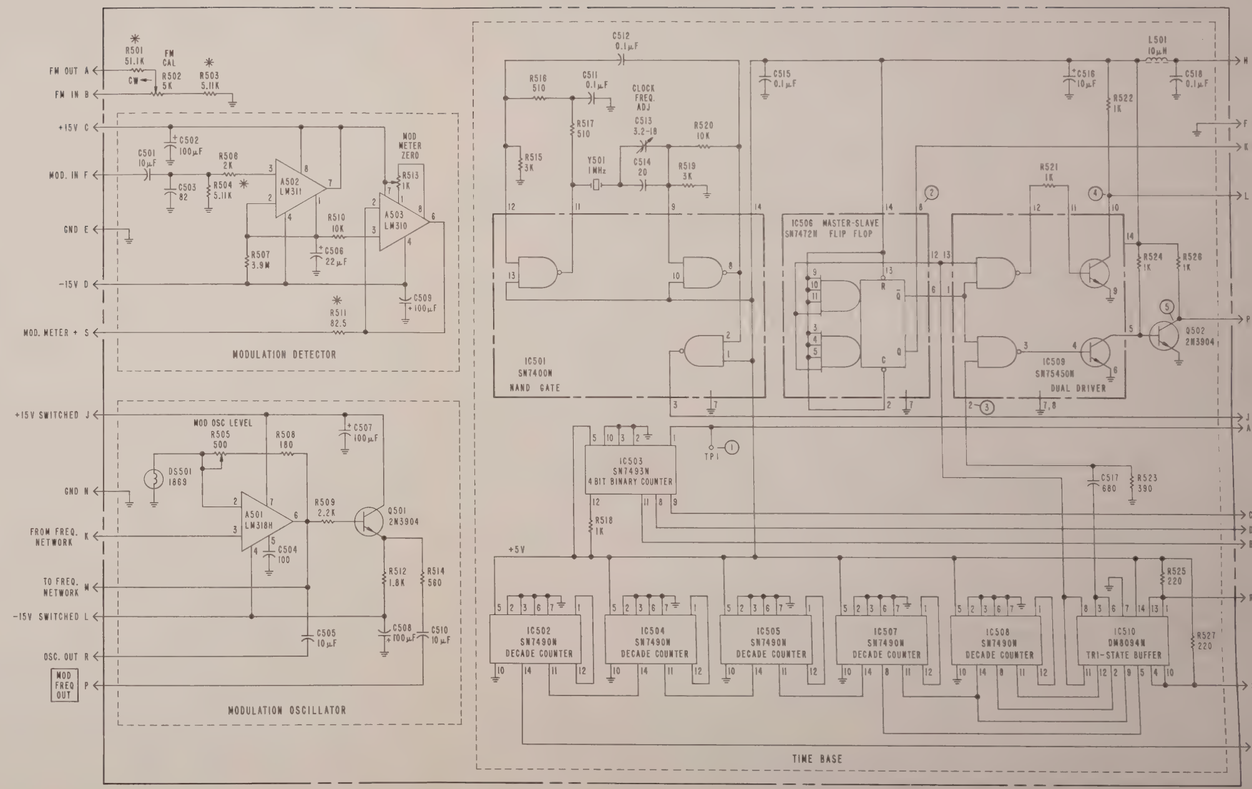


Figure 6-3 Modulation Oscillator, Detector and Time Base PCB, Schematic Diagram

D830594A

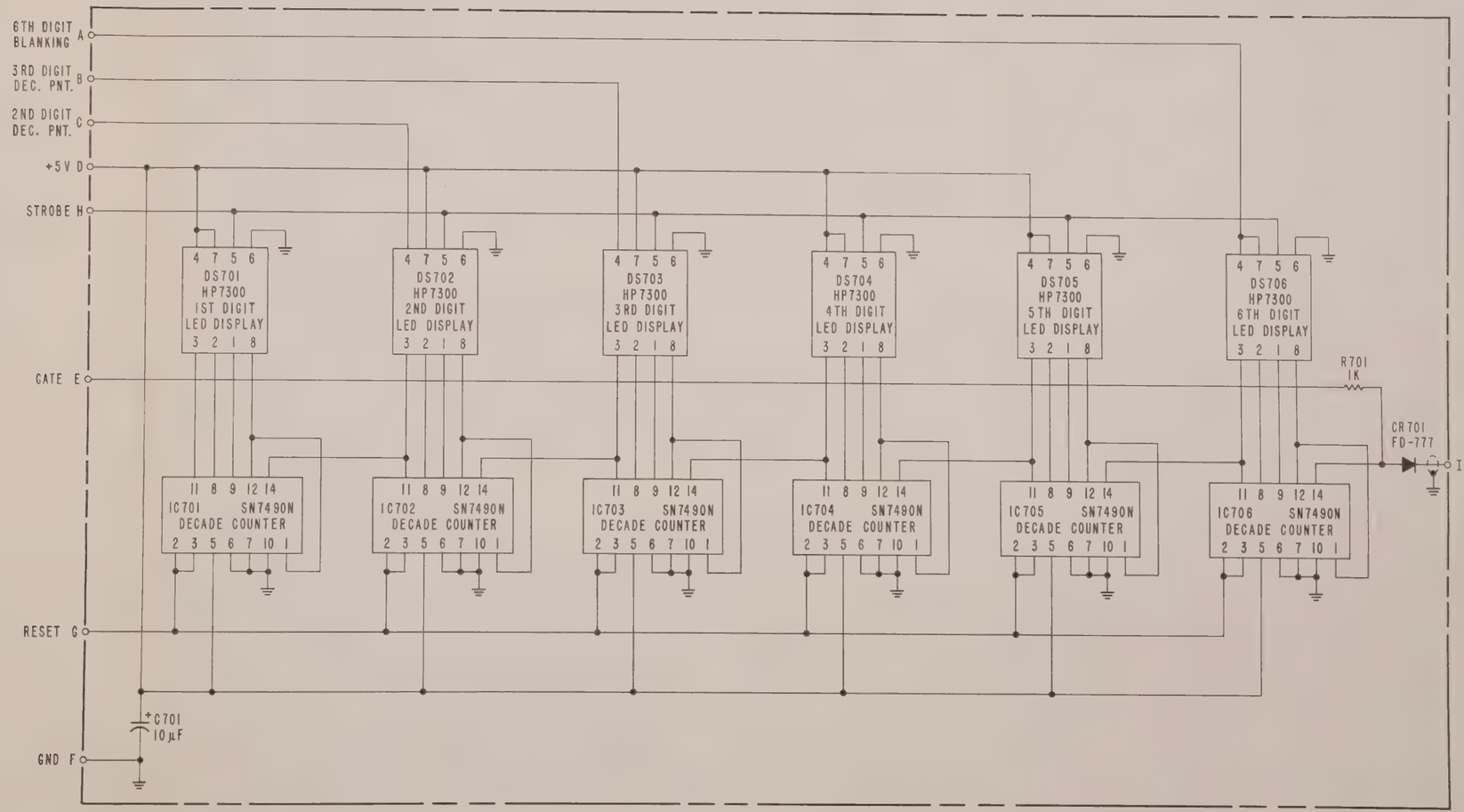
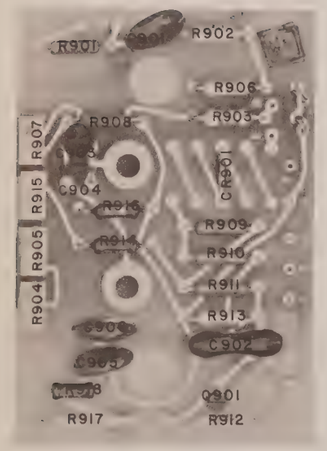
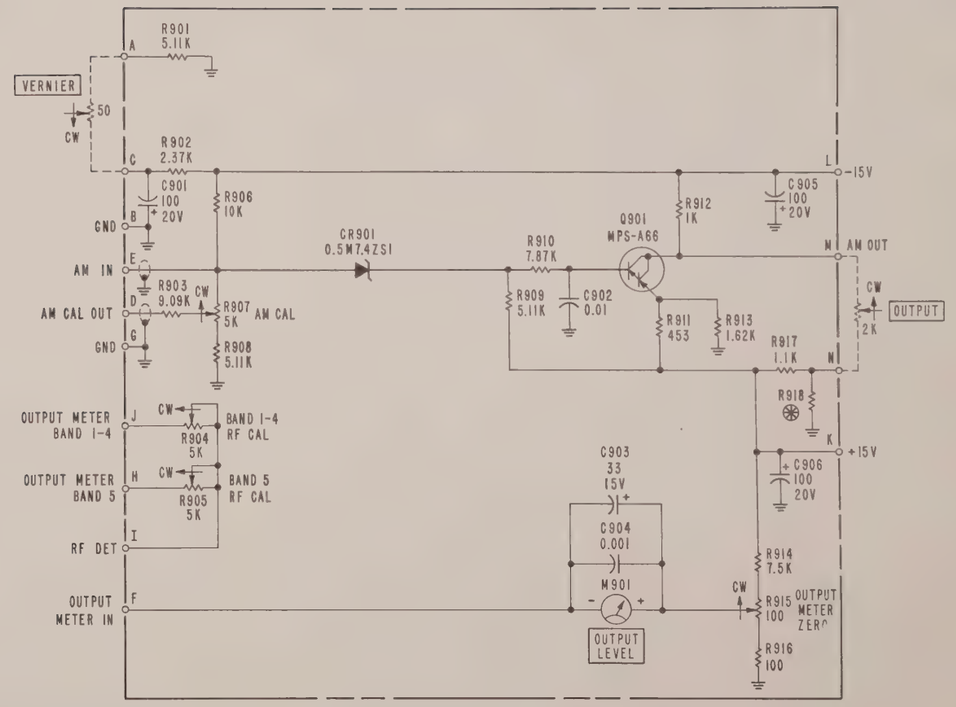

6TH DIGIT BLANKING A
3RD DIGIT DEC. PNT. B
2ND DIGIT DEC. PNT. C
+5V D
STROBE H
GATE E
RESET G
GND F
4 7 5 6
DS701 HP7300 1ST DIGIT LED DISPLAY
3 2 1 8
DS702 HP7300 2ND DIGIT LED DISPLAY
DS703 HP7300 3RD DIGIT LED DISPLAY
DS704 HP7300 4TH DIGIT LED DISPLAY
DS705 HP7300 5TH DIGIT LED DISPLAY
DS706 HP7300 6TH DIGIT LED DISPLAY
11 8 9 12 14
IC701 SN7490N DECADE COUNTER
IC702 SN7490N DECADE COUNTER
IC703 SN7490N DECADE COUNTER
IC704 SN7490N DECADE COUNTER
IC705 SN7490N DECADE COUNTER
IC706 SN7490N DECADE COUNTER
2 3 5 6 7 10 1
R701 1K
CR701 FD-777
I INPUT
+C701 10 µF

Figure 6-4 Display and Counter PCB, Schematic Diagram

C830594E



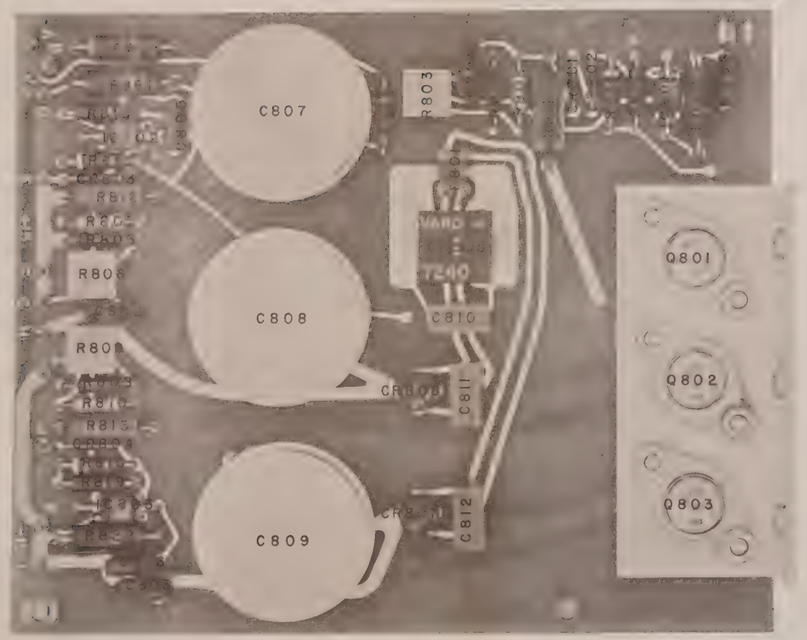


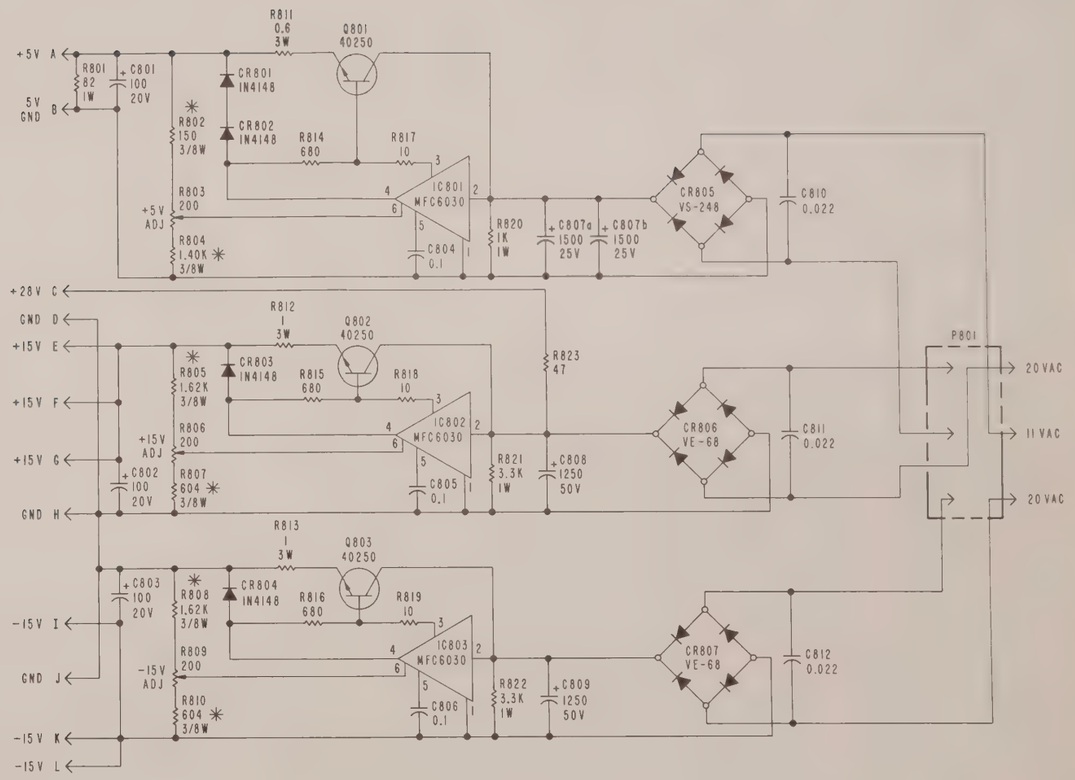
NOTES:

1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 3/8 WATT, UNLESS OTHERWISE SPECIFIED.
3. ALL RESISTORS TO BE PRECISION EXCEPT R904, R905, R907 AND R915.
4. ☐ EXTERNAL MARKINGS.
5. LAST NUMBERS USED:
   R918 C906
6. ⊛ FACTORY SELECTED VALUE.

Figure 6-5 Meter and Level Adjust PCB, Schematic Diagram

D830594B





NOTES:
1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTOR.
4. LAST NUMBERS USED:
   R823 C812

Figure 6-6 Power Supply PCB, Schematic Diagram

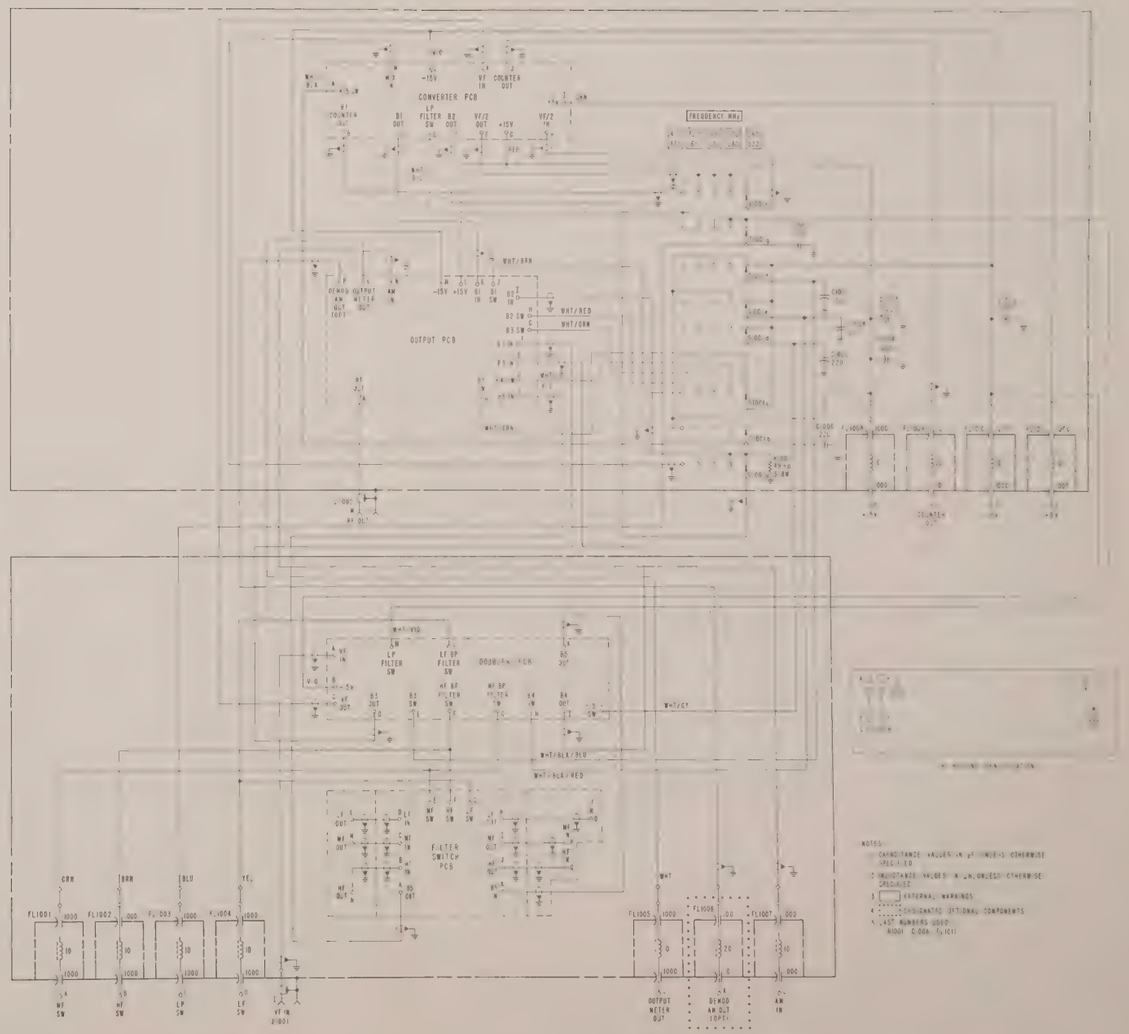
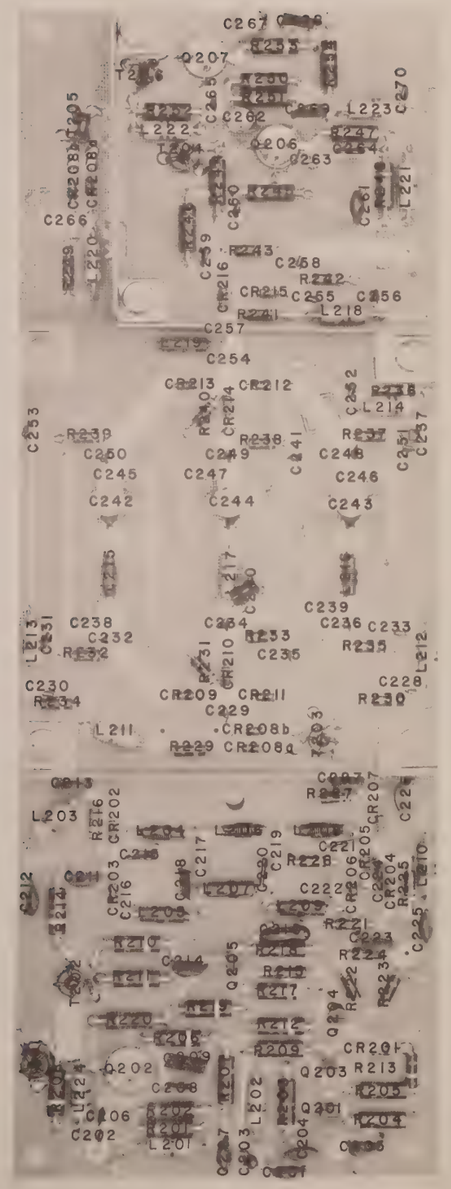


Figure 6-7 RF Housing, Interconnection Diagram

NOTES:

1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. INDUCTANCE VALUES IN μH, UNLESS OTHERWISE SPECIFIED.
3. RESISTANCE VALUES IN OHMS AND 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
4.
5. ⊛ FACTORY SELECTED.
6. ALL DIODES TO BE H.P.* 5082-3080, UNLESS OTHERWISE SPECIFIED.
7. LAST NUMBERS USED:
   R254 C270 L224 CR216
8. NUMBERS NOT USED:
   R228

E830594C



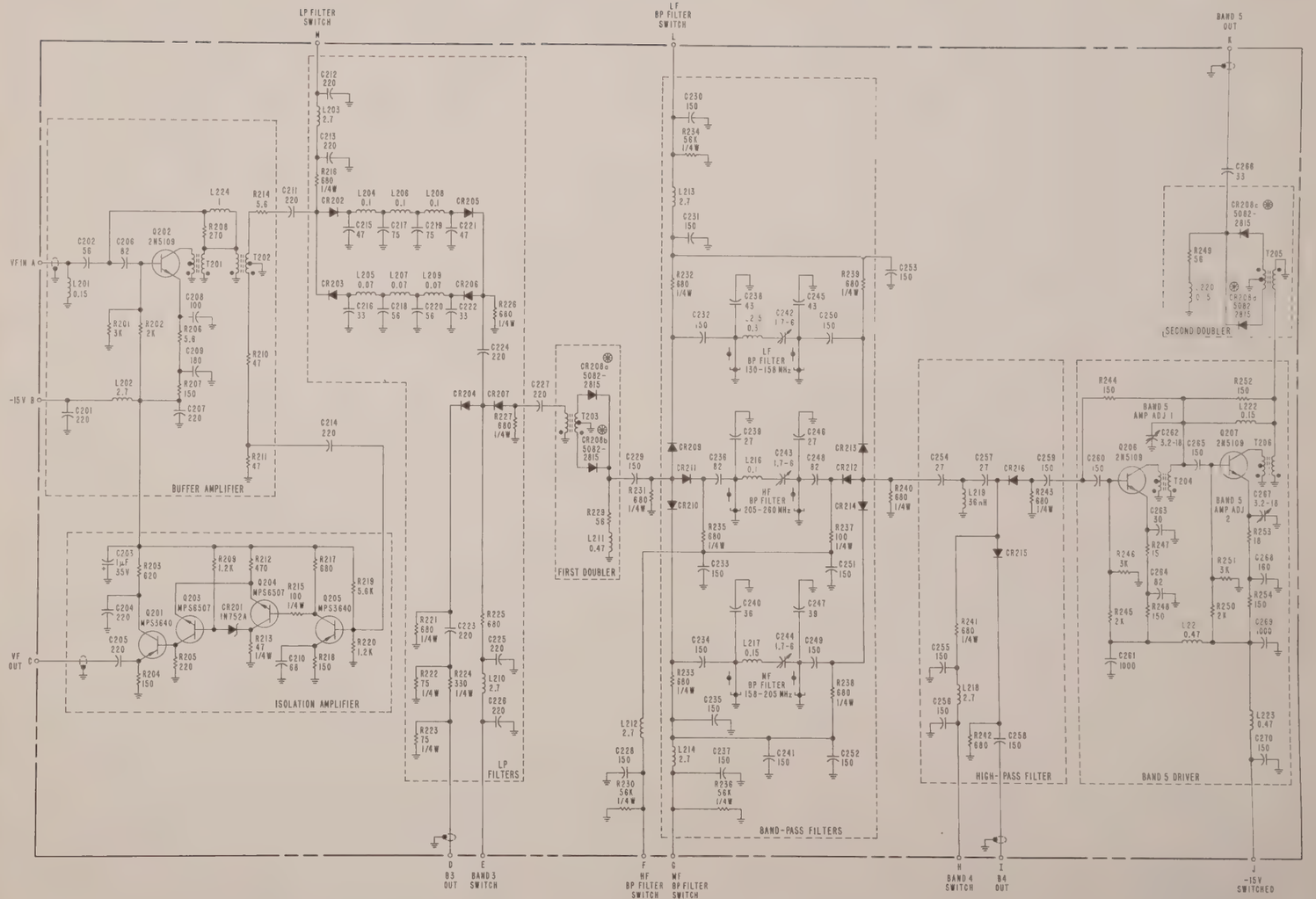
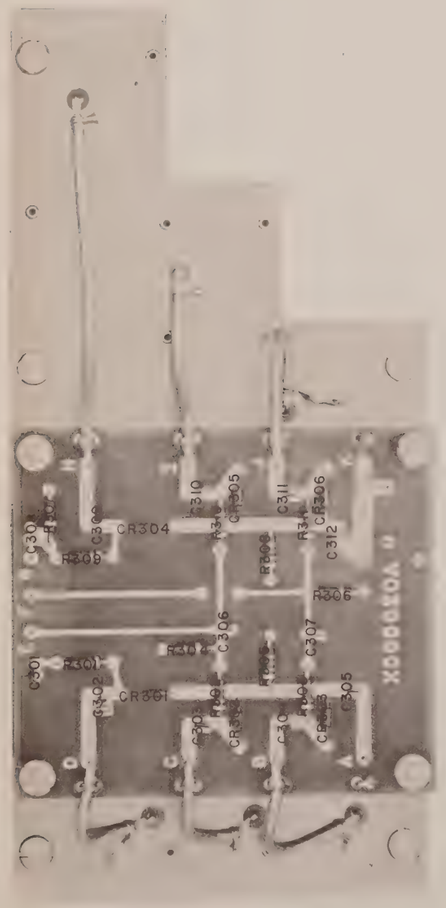
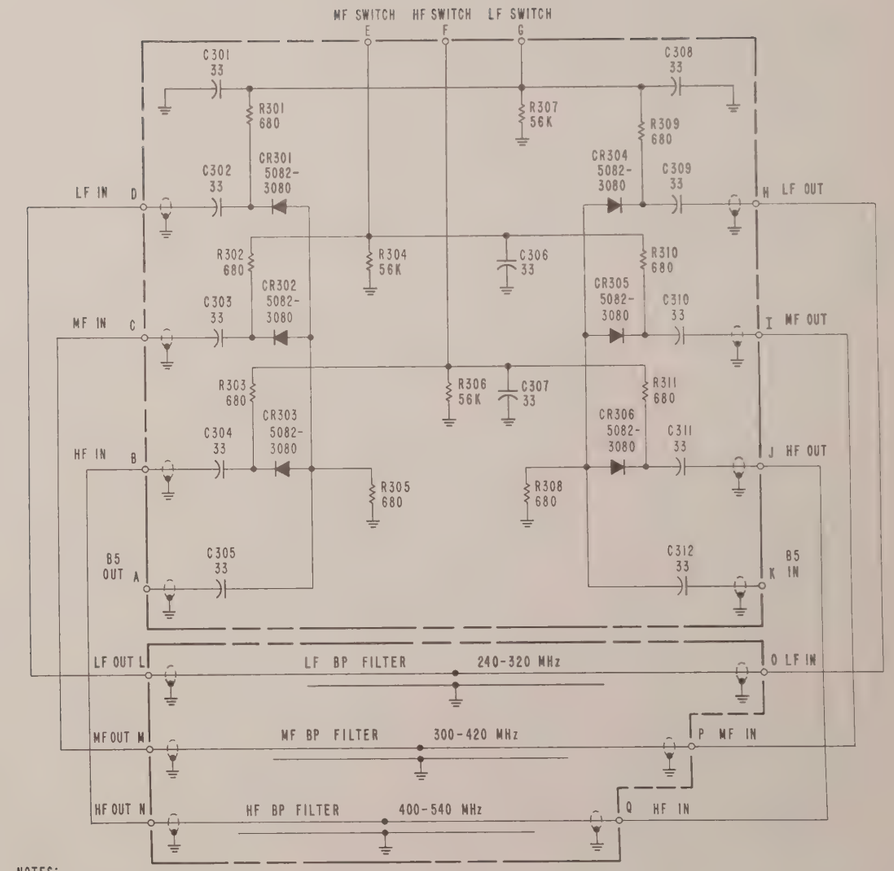


Figure 6-8 HF Doublers and Filters PCB, Schematic Diagram

0830594A

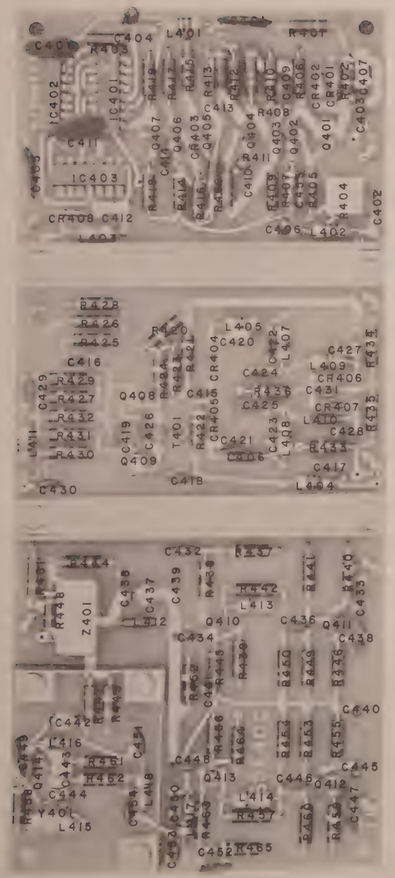




NOTES:

1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
3. LAST NUMBERS USED:
   R311 C312 CR306

Figure 6-9 Band 5 Filters and Switches PCB, Schematic Diagram

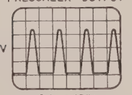


B830594F

NOTES:

1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
3. INDUCTANCE VALUES IN µH, UNLESS OTHERWISE SPECIFIED.
4.
5. LAST NUMBER USED:
   R466 C455 L418 Q414
6. NUMBERS NOT USED:

WAVEFORM



TEST POINT ①

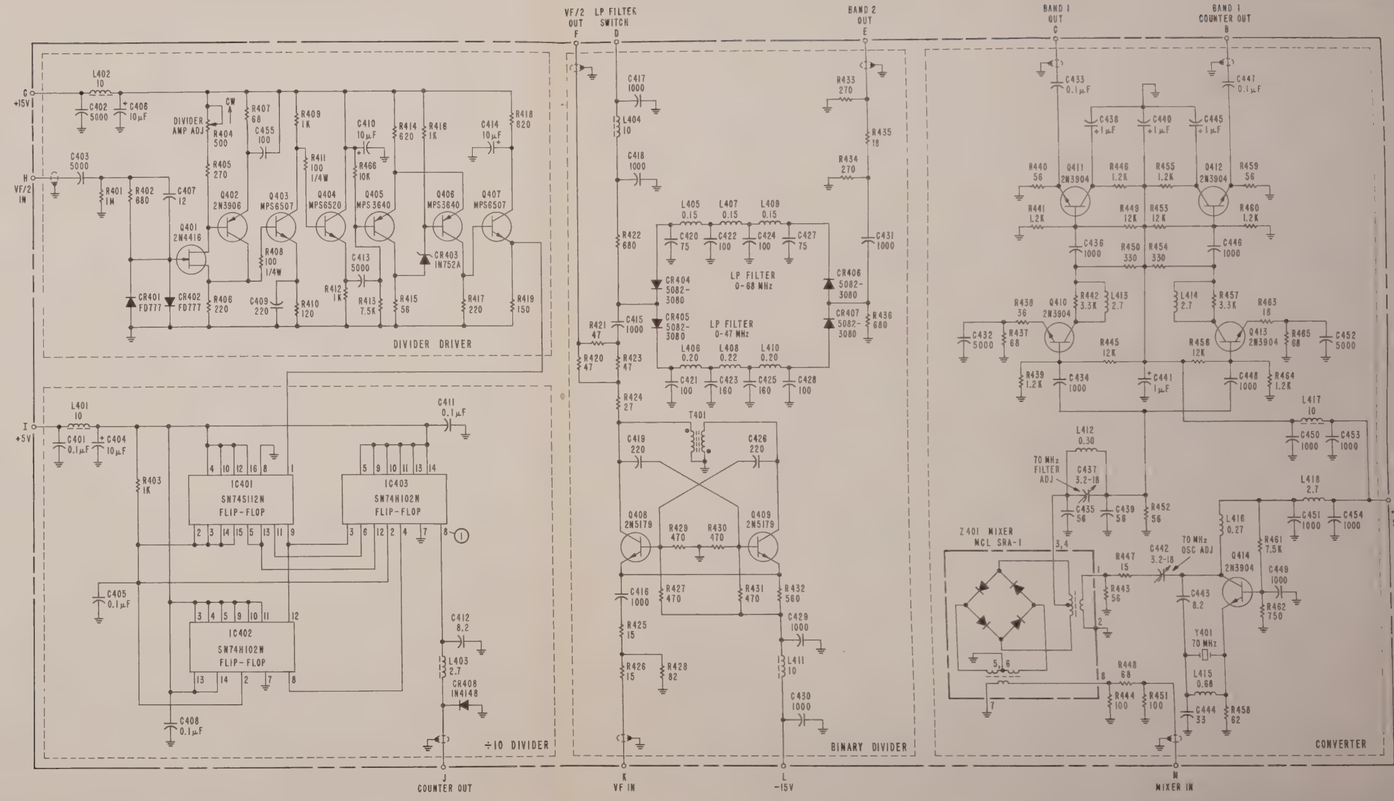
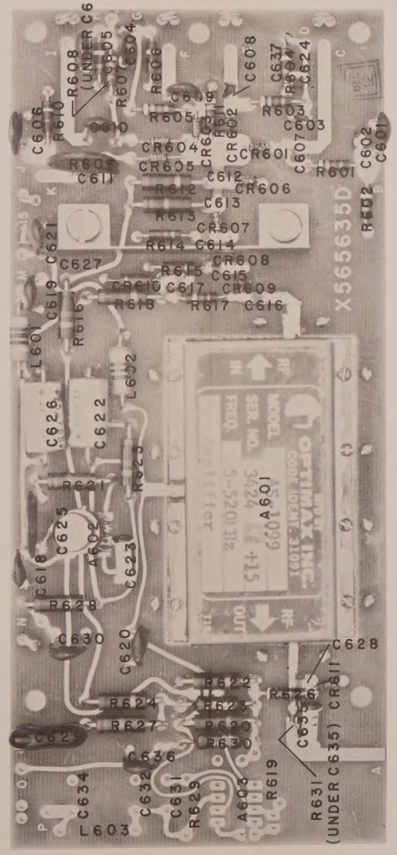
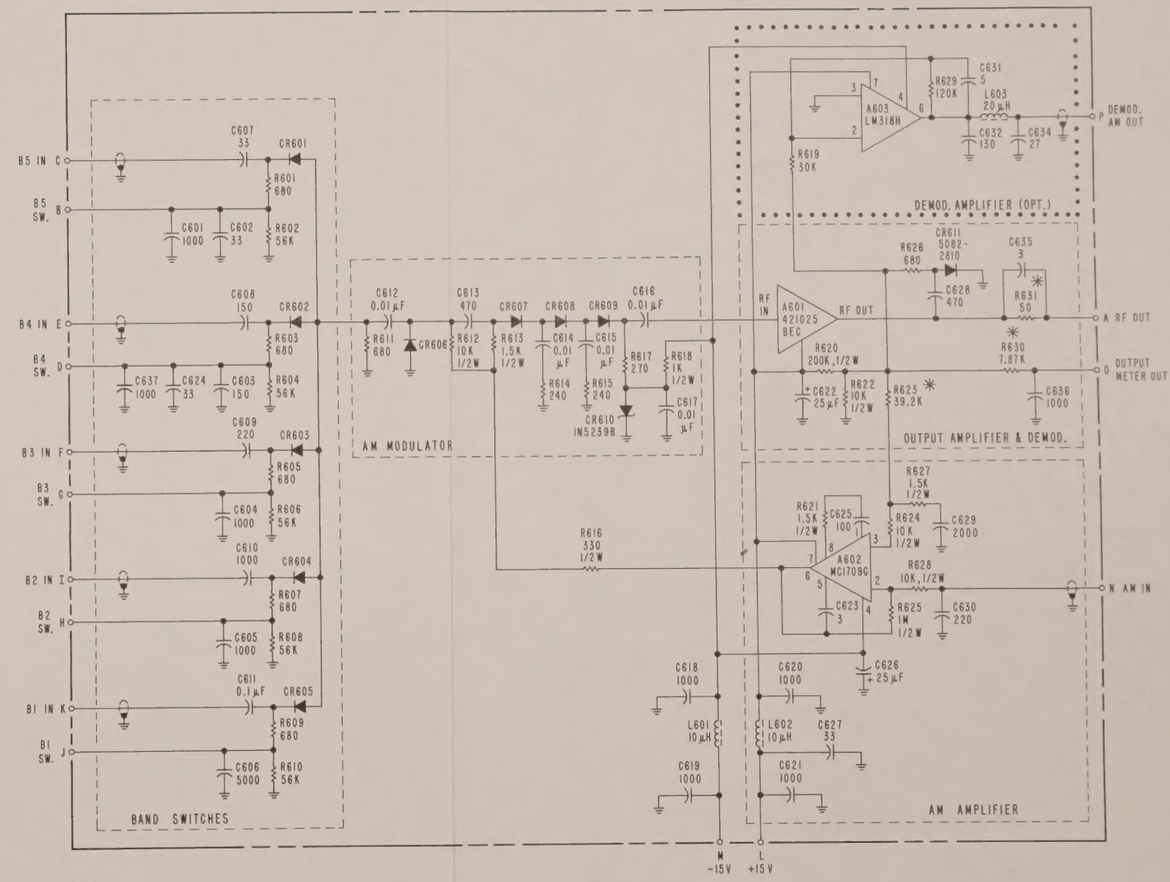


Figure 6-10 Divider and Converter PCB, Schematic Diagram

D830594E





NOTES:
1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTORS.
4.
5. ⋮⋮⋮ SIGNIFIES OPTIONAL COMPONENTS.
6. LAST NUMBERS USED:
   R631 C637
7. ALL DIODES HP 5082-3080, UNLESS OTHERWISE SPECIFIED.
8. NUMBERS NOT USED:
   C633

Figure 6-11 Output Amplifier and Modulator PCB, Schematic Diagram

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